Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

1010 EMPIRE BUILDING

February, 1943

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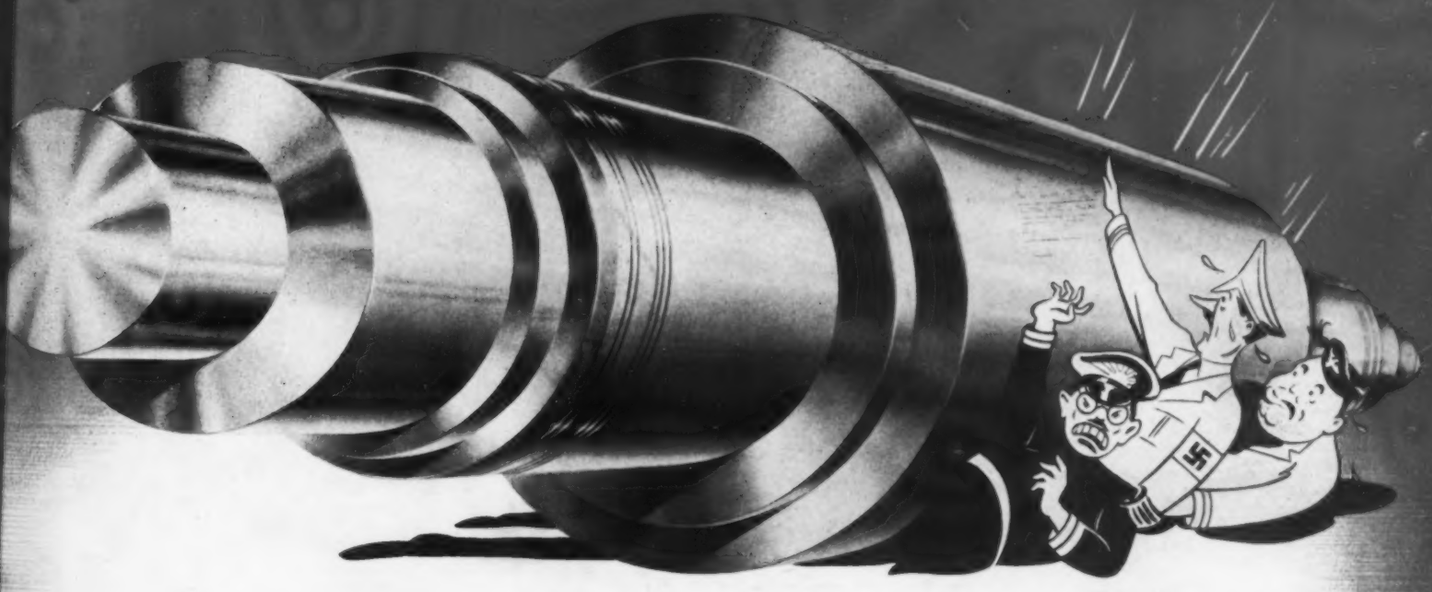
MAR 31 1943
DETROIT

Ohio Rolls ARE HELPING FLATTEN THE AXIS!

The battle of production that is flattening the Axis is being waged on thousands of fronts. OHIO ROLLS are helping in this battle. Mill men everywhere take advantage of the many fine features of these rolls.



CARBON STEEL ROLLS • ALLOY STEEL ROLLS • ALLOY IRON ROLLS • NICKEL CHILL ROLLS • FLINTUFF ROLLS
PLAIN CHILLED IRON ROLLS • MOLYBDENUM CHILL ROLLS • DENSO-IRON ROLLS • HOLL-O-CAST ROLLS

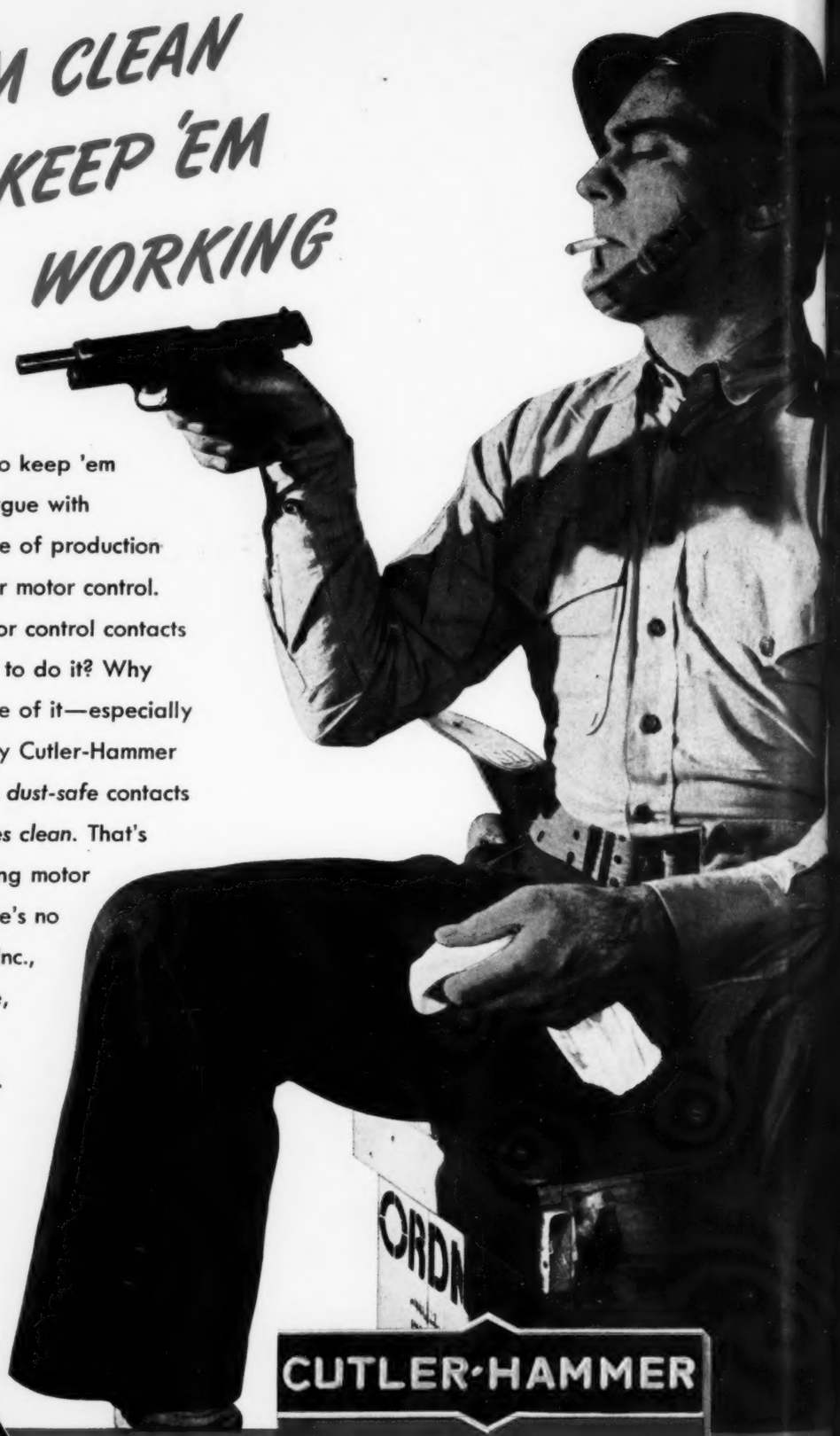
THE OHIO STEEL FOUNDRY COMPANY

Engineers • Founders • Machinists

LIMA, OHIO • SPRINGFIELD, OHIO

ARMY E NAVY

KEEP 'EM CLEAN TO KEEP 'EM WORKING



You don't have to argue with a man up at the front that it's just good sense to keep guns clean to keep 'em working. Nor do you have to argue with experienced men on the front line of production that the same thing holds true for motor control. Of course you *have to* keep motor control contacts clean . . . but *how* are you going to do it? Why make an *extra* maintenance chore of it—especially when men are so scarce? Specify Cutler-Hammer Motor Control with the VERTICAL *dust-safe* contacts that *shed* dirt and *keep themselves clean*. That's the direct way of insuring unfailing motor control performance . . . and there's no extra cost. CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ont.

CUTLER-HAMMER
MOTOR CONTROL
C-H

Cutler-Hammer Vertical Contacts

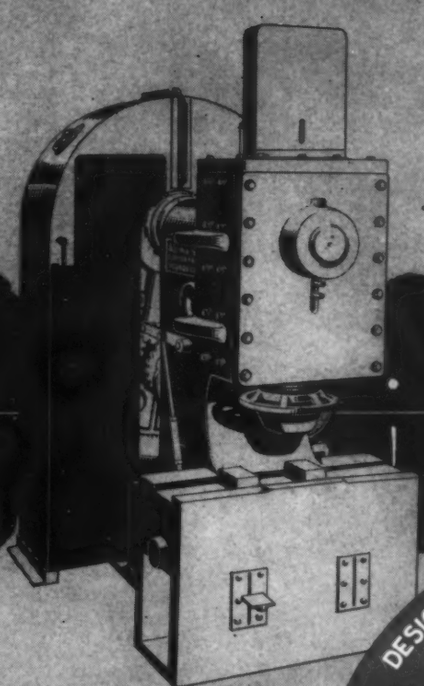
OUT IN THE OPEN—NOTHING TO HIDE—You can see the clean contacts in Cutler-Hammer Motor Control as soon as you open the case. They're out in the open where they can work cooler and last longer.

Copyright 1943, Cutler-Hammer, Inc.

SYMBOLS OF FREEDOM

A POINTED REMINDER

The Washington Monument is a tribute to one of America's most honored heroes. Here was a man, raised in luxury and well able to afford all of the comforts of that time, who instead, willingly chose sacrifice and privation that a nation might be born. And today, if our homes are uncomfortably cold, or we can't drive wherever we please, or buy whatever we think of, let's reflect and be worthy of the democracy for which men died at Valley Forge.



The Aetna Straightening Press for bars, rounds, squares, rectangular sections and other shapes suitable for press straightening. Operates at a speed of forty strokes per minute with a maximum ram-pressure of 200 tons. Dies are quickly interchangeable.

ARMY E NAVY

DESIGNERS AND BUILDERS TO THE STEEL

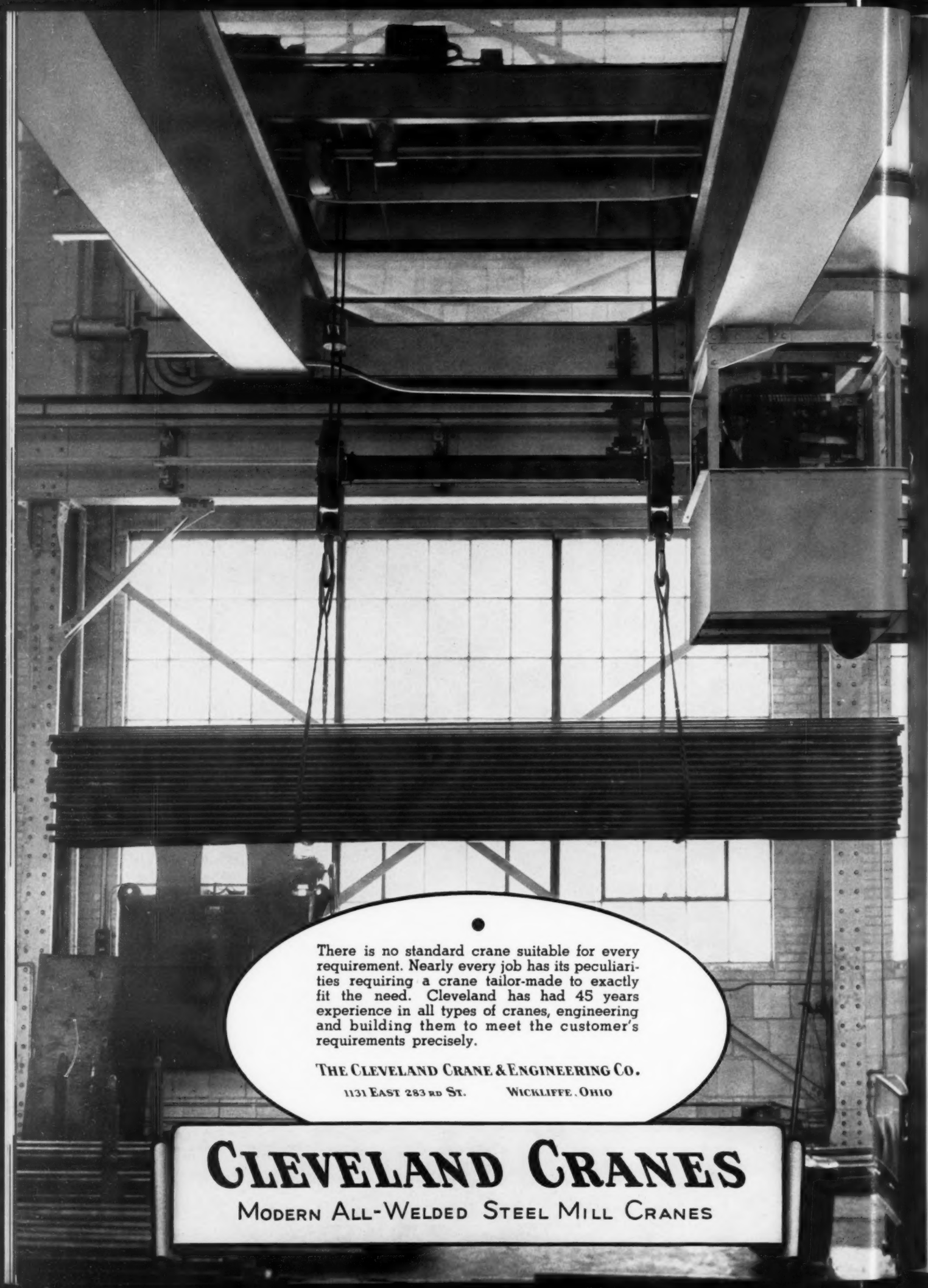
The AETNA-STANDARD ENGINEERING COMPANY

★ YOUNGSTOWN, OHIO, U.S.A. ★

NON-FERROUS AND CHEMICAL INDUSTRIES

ASSOCIATED COMPANIES

HEAD, WRIGHTSON & COMPANY, LIMITED, THORNABY-ON-TEES, ENGLAND •
JOHN INGLIS COMPANY, LIMITED, TORONTO, ONTARIO, CANADA


There is no standard crane suitable for every requirement. Nearly every job has its peculiarities requiring a crane tailor-made to exactly fit the need. Cleveland has had 45 years experience in all types of cranes, engineering and building them to meet the customer's requirements precisely.
THE CLEVELAND CRANE & ENGINEERING CO.
1131 EAST 283 RD ST. WICKLIFFE, OHIO
CLEVELAND CRANES
MODERN ALL-WELDED STEEL MILL CRANES

Crops *and* Shorts

WHILE the eastern seaboard shivers because of a lack of fuel oil, 500,000,000 cu ft of natural gas is being wasted daily in eastern coal mining fields, according to Leo Ranny, of Columbus, Ohio. New developments in horizontal drilling, it is stated, may make it profitable to tap huge quantities of gas now absorbed in unmined coal. At the same time, the coal mines would be made safer by this removal of the deadly firedamp.

▲

SOME relief in the oil situation is expected from the recent completion of the 551 mile 24 in. pipeline from Texas to Illinois. This line has been connected to a system extending across Ohio to Pennsylvania, thus augmenting rail service. Work is progressing on the 857 mile leg from Illinois to the east coast. Completion of this leg, expected this summer, will be equivalent to 85 tankers.

▲

ORGANIZED labor has relinquished the strike as a weapon for the duration of the war" — it says in a report for 1942 issued by the War Production Board.

▲

AN estimated 2,625,000 tons of tinplate, exclusive of ternes and bonderized black plate, were produced in 1942, the industry operating at about 65 per cent of capacity and coating 55,000,000 base boxes. Practically all of this was cold reduced material. Under complete war economy control, the tinplate output in 1943 will approximate 2,650,000 tons. Much of the 1943 production will be coated electrolytically, although all of the new electrolytic tinning lines will not be in operation until late in the year.

▲

THE improvement made by OPA in changing their instructions on the preservation of feminine girdles from the original "It can be removed best by a good strong yank" to the new "It can be removed quickly by a good strong jerk" reminds us of the man, who wanted to change his name from Herman Stink to John Stink.

WHAT ever became of the old-fashioned meetings on costs and man-hours so popular in the nineteen-thirties?

▲

THE United States Government, through the Office of Alien Property Custodian, now holds about 50,000 patents formerly owned by residents of enemy and enemy-occupied countries. The inventions disclosed in these patents represent research achievements of great potential value in a wide range of industrial fields. The patents are offered for use by American industry. Applications for licenses to use these patents are granted by the Office of Alien Property Custodian.

▲

REMEMBER when labor ran their own unions and didn't have to strike on their jobs to set union dues where they wanted them?

▲

HERE is one enemy for the home front to work on. During one year since Pearl Harbor, more American workers were killed by accidents, either on or off the job, than men, women and children in Great Britain by German bombings. In addition to the 46,300 killed, 4,000,000 workers were injured, 165,000 of them permanently, giving a total loss of 450,000,000 man-days. This would make a lot of tanks and guns, or conversely, it would require a lot of enemy effort to inflict this loss.

▲

ONE solution of the manpower problem might be to have the men left on the jobs put in a full week's work.

▲

FROM the crystal ball comes the prognostication for post-war steel production averaging 65,000,000 tons per year for 10 years. While this might look like a vacation after 86,000,000 tons a year, 'tain't exactly hay.

▲

IT is estimated that the foundries of the United States have a total annual capacity of approximately 3,000,000 tons of electric furnace steel. This figure added to the present electric ingot-making capacity of 5,000,000 tons per year brings electric furnace products up to a substantial proportion of our total steel capacity. Incidentally, a few extra copies of the complete tabulation of ingot-making electric furnaces, as published in the January issue of Iron and Steel Engineer, are available.

Keep the steel moving for Victory—put all table rolls on Timken Bearings. This also will help you to overcome post-war conditions.

Timken Tapered Roller Bearings keep mill table rolls turning swiftly, smoothly, dependably despite heat, load and shock; require very little attention for lubrication and maintenance.

In order to take full advantage of Timken Bearings however, all table rolls should be equipped with them. Otherwise the Timken Bearing Equipped tables would not be able to operate at the full efficiency of which they are capable.

Existing mill tables can be equipped with Timken Bearings. Consult the mill builder or Timken Company engineers.

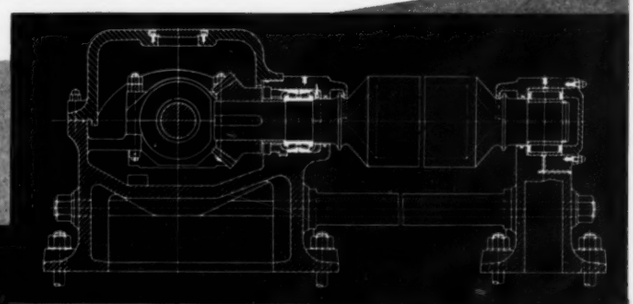
THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN

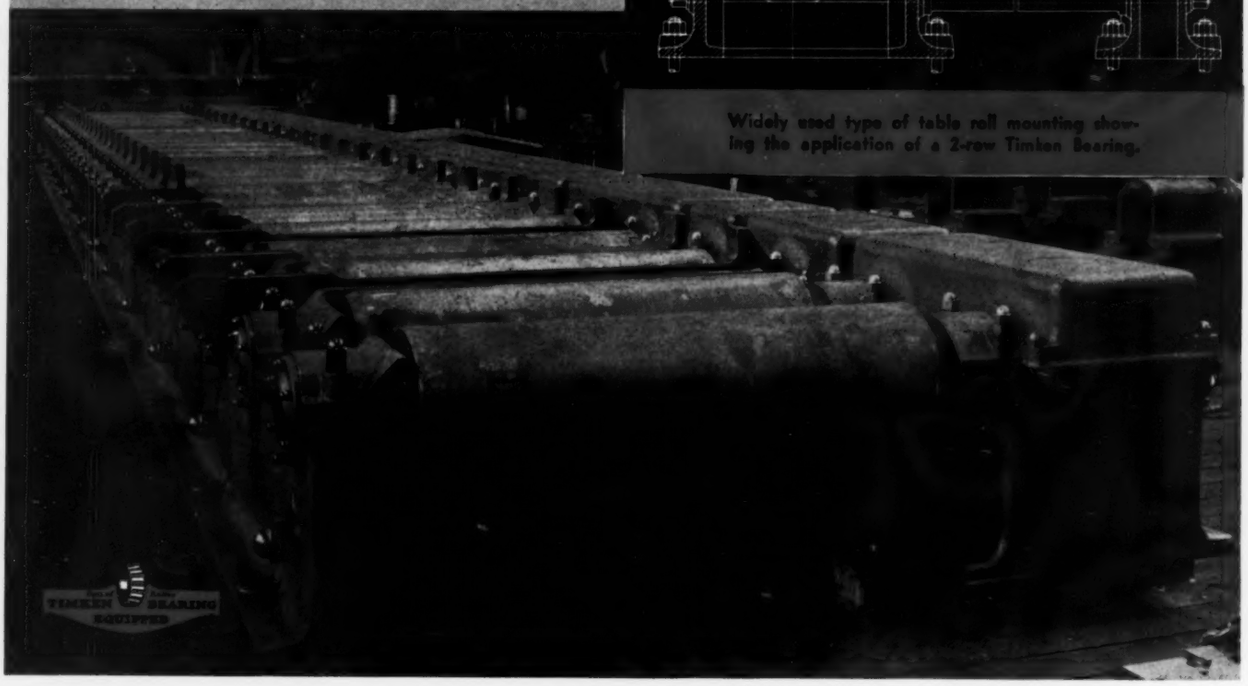
TRADE-MARK REG. U. S. PAT. OFF

TAPERED ROLLER BEARINGS

"All There Is In Bearings"



Widely used type of table roll mounting showing the application of a 2-row Timken Bearing.



Typical mill table with Timken Bearing Equipped rolls.

HELP ASSURE VICTORY

Buy War Bonds. Conserve Rubber. Eliminate Unnecessary Travel. Use the Telephone Only When Important. Salvage All Scrap and Waste Material.

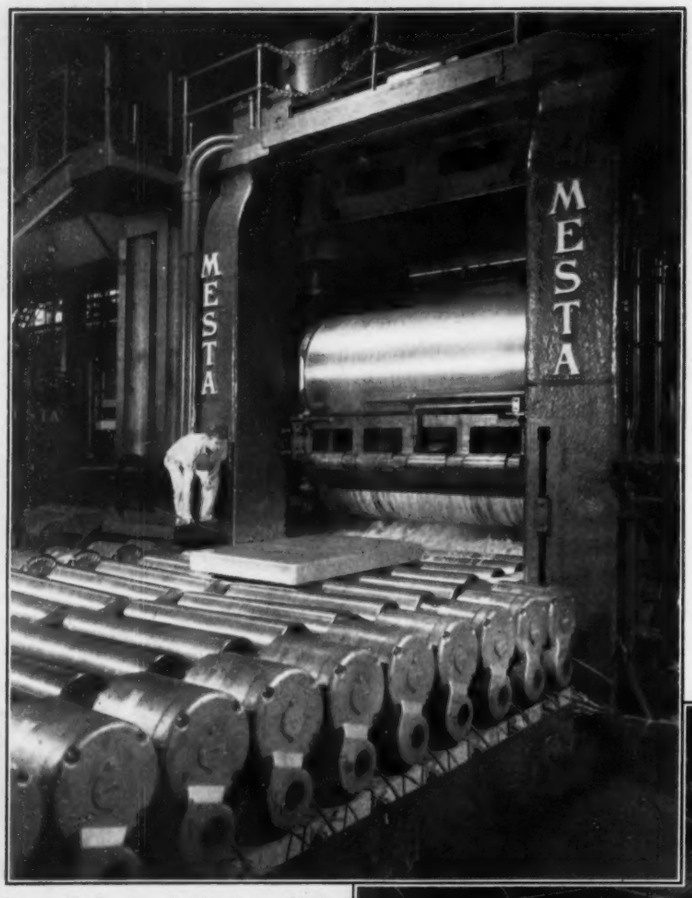
All Timken Bearing production now goes into fighting machines. However, the Timken Bearings in your motor vehicles or industrial machines will see you through the emergency—and beyond it—if you make sure they are lubricated and inspected regularly.

PITTSBURGH ROLLS

PITTSBURGH ROLLS DIVISION of

BLAW-KNOX CO.—"Steel's Partner" • PITTSBURGH, PA.

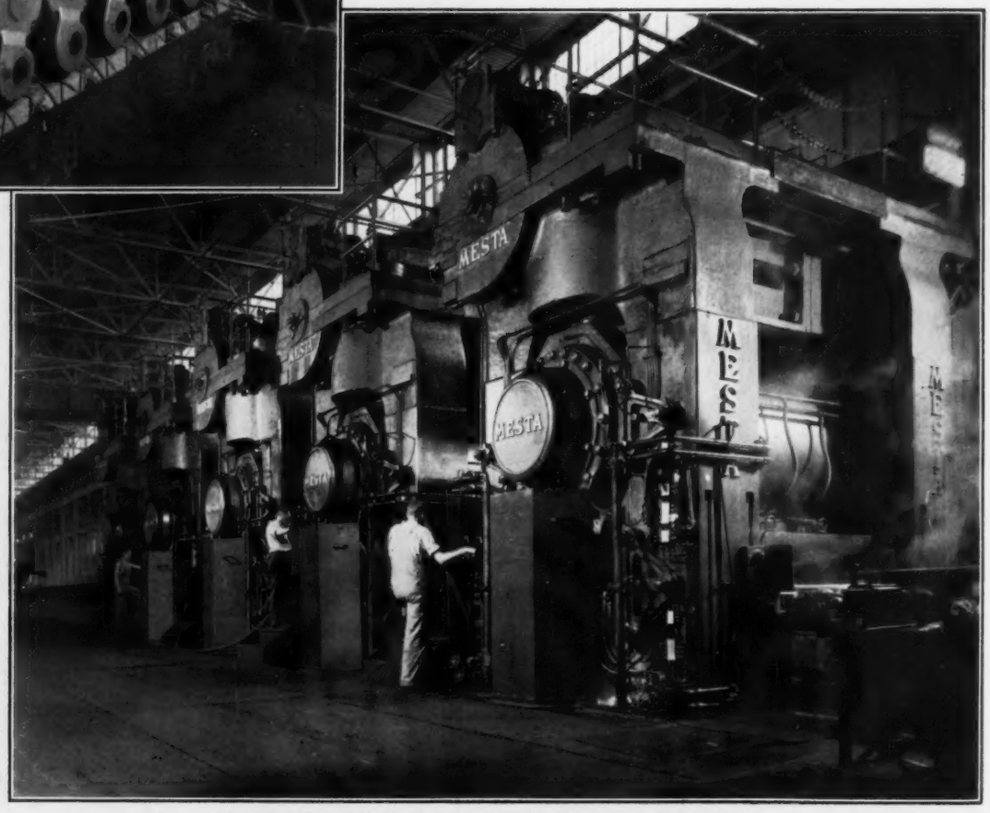
MESTA FOUR HIGH MILLS



Partially Reduced Aluminum Slab at Roughing Mill

for... *Rolling* ALUMINUM and other NON-FERROUS METALS

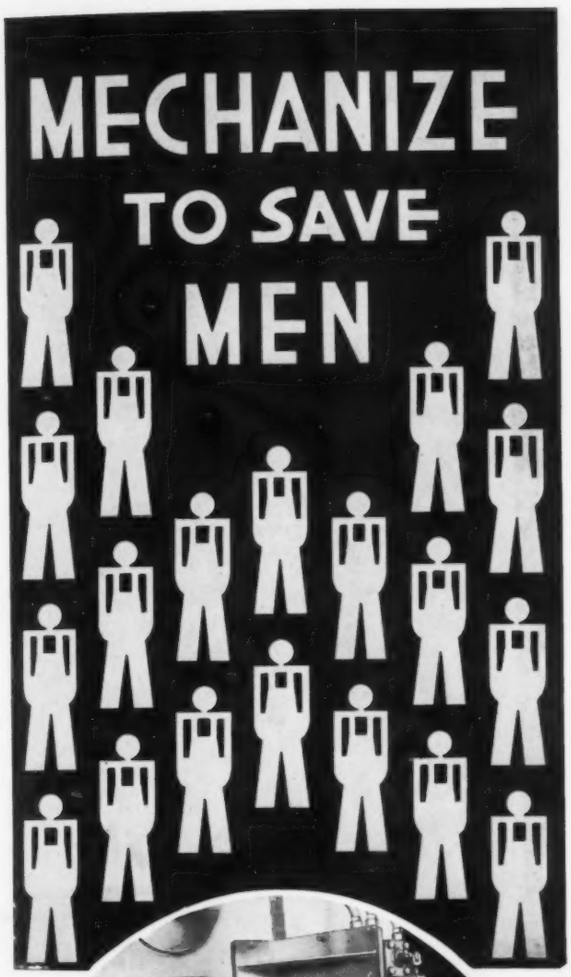
The Army-Navy "E" Flag with two stars, flies over the Mesta plant.



The First Four-High Tandem Mill Installed in This Country For the Production of Wide Aluminum Strip Sheets

MESTA MACHINE COMPANY . . PITTSBURGH, PA.

ROLLS AND STEEL MILL EQUIPMENT
HEAVY DUTY MACHINE TOOLS
CASTINGS · FORGINGS



10 to 20 Hand Chippers Can be Transferred to More Productive Work

Wouldn't you say that using ten to twenty men on a job that can be done by ONE man is a waste of man-power?

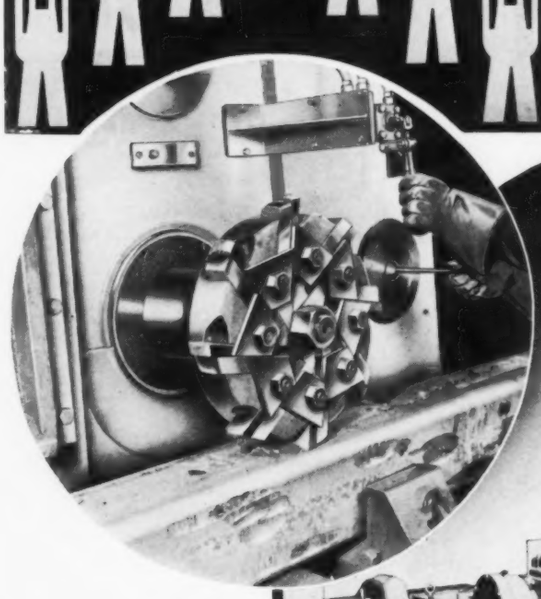
Yet Victory efforts are being handicapped today, in many instances, by conditioning heavy tonnages of billets with slow, out-dated hand methods, which at best require ten times more man-hours than when using

BILLETEERS

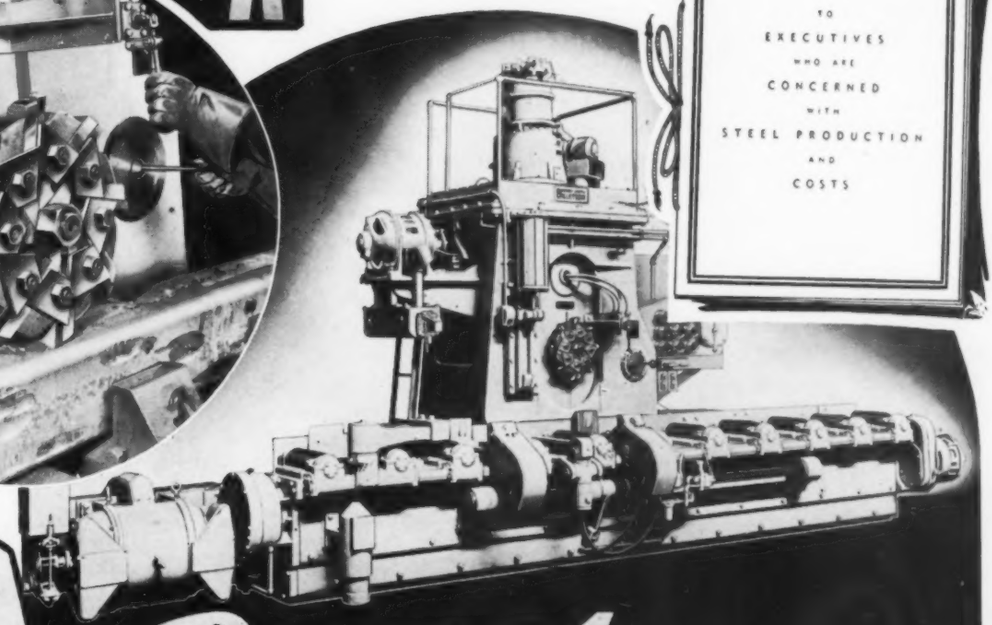
The Billeteer is built for action! Every operation is accurately controlled from the instant the operator presses the button that rolls a billet off the feed skids onto the machine, to the final movement of the thoroughly cleaned billet over the discharge table.

The demand for Billeteers outstrips our production facilities — which is all the more reason you should talk with one of our sales engineers *without delay*. Very high priority rating is given this equipment.

Send for our descriptive Brochure. It gives information vital to every steel plant engineer and production executive.



TIMKEN ROLLER BEARING EQUIPPED



BUILDERS OF BONNOT-LENTZ BILLETEERS ALSO CRUSHING PULVERIZING AND MIXING EQUIPMENT

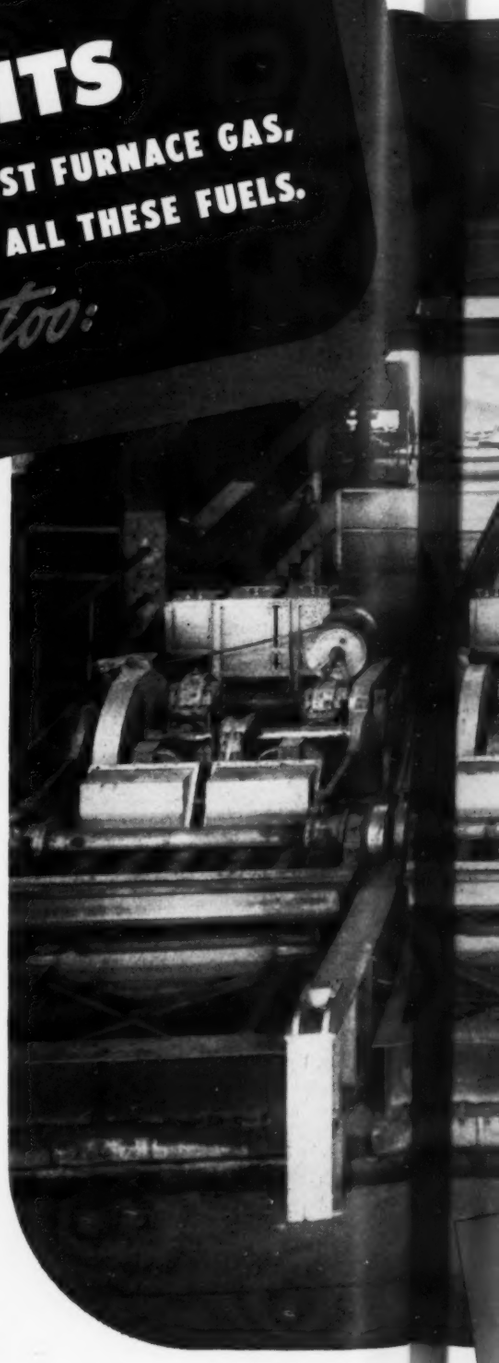
THE Bonnot COMPANY
STEEL EQUIPMENT DIVISION
CANTON, OHIO

FOR ANY

SC ONE-WAY PITS

CAN BE FIRED WITH COKE GAS, NATURAL GAS, BLAST FURNACE GAS, FUEL OIL, PRODUCER GAS, OR A COMBINATION OF ALL THESE FUELS.

Other Advantages too:



★ **Increased Ingot Yield**—Safe firing at maximum rates permits maximum speed in heating steel. One-way pit arrangement doubles ingot capacity for given floor area.

★ **Steel Quality Protected**—Flame travels across top of ingots, not directly against them. Pit temperatures are uniform and accurately controlled. No burned ingots.

★ **Fuel Economy**—Scientific burner design, preheating of air, efficient flame travel, automatic control, adequate pit insulation produce maximum firing efficiency and minimum fuel consumption.

Best evidence of the superiority of one-way fired soaking pits is this: They are proving themselves in war production of steel—over two hundred SC pits in the leading steel plants.

These SC pits are being operated on every type of fuel gas—coke oven gas, natural gas, producer gas, blast furnace gas—also on fuel oil and various combinations of fuels.

To see for yourself how efficiently one-way fired pits operate on any type of fuel, let Surface Combustion engineers arrange to take you to inspect two or three or more installations at work.

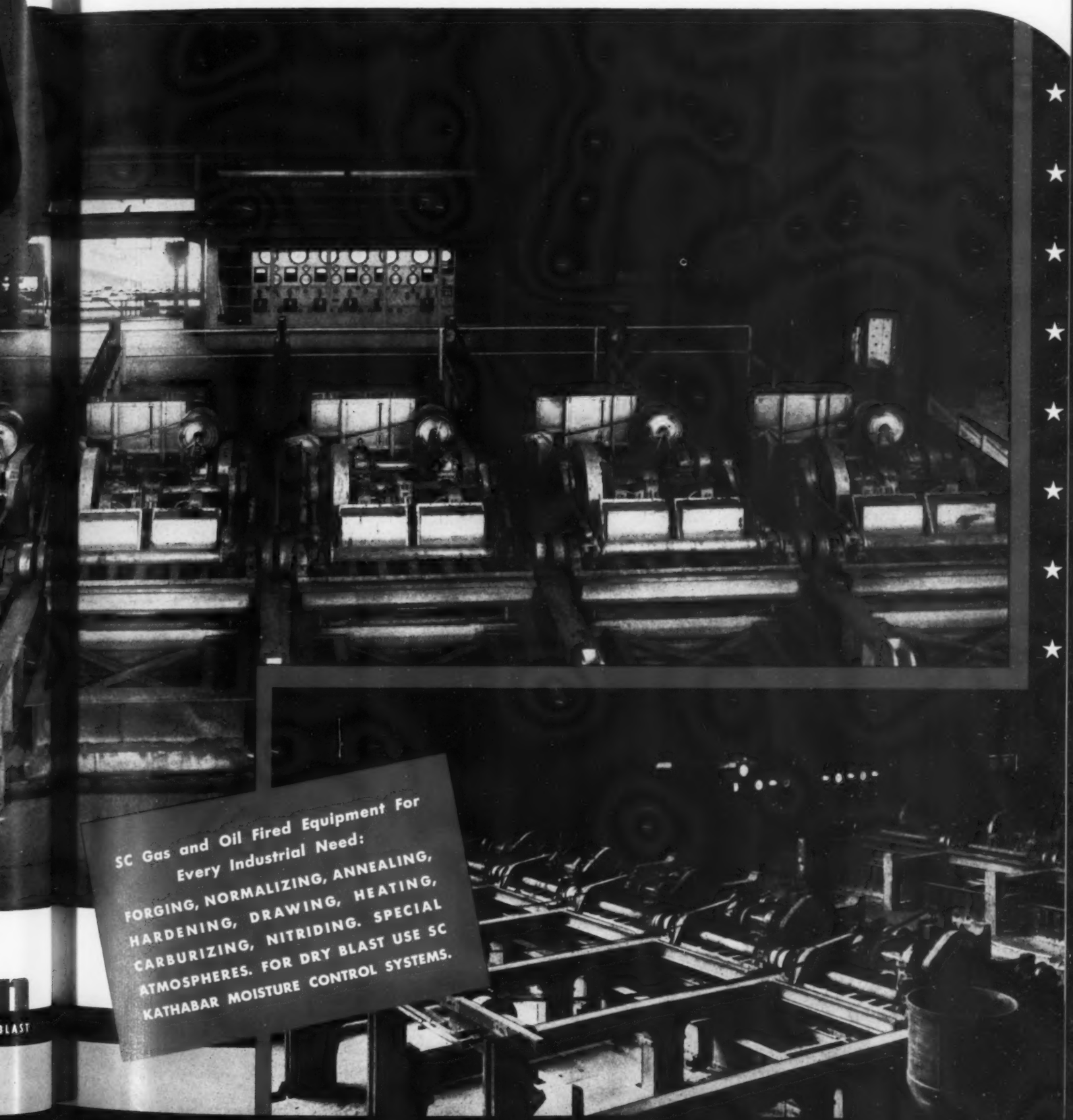
Seeing is believing. We invite you to convince yourself that SC one-way pits can speed up your own ingot production, safeguard steel quality and save you money.

SURFACE COMBUSTION • TOLEDO, OHIO

SURFACE SC COMBUSTION

MANUFACTURERS OF INDUSTRIAL FURNACES • JANITROL GAS-FIRED SPACE HEATING EQUIPMENT • AND KATHABAR SYSTEMS FOR DRY BLAST

COMMERCIAL FUEL!



SC Gas and Oil Fired Equipment For Every Industrial Need:

FORGING, NORMALIZING, ANNEALING, HARDENING, DRAWING, HEATING, CARBURIZING, NITRIDING. SPECIAL ATMOSPHERES. FOR DRY BLAST USE SC KATHABAR MOISTURE CONTROL SYSTEMS.

LEWIS

Up and Down cut SHEAR

LEAVES THE SLAB STRAIGHT AND TRUE AFTER CROPPING

This new 1350-ton Lewis Heavy Duty Cold Slab Shear is saving time on the Victory Program.

LEADING FEATURES

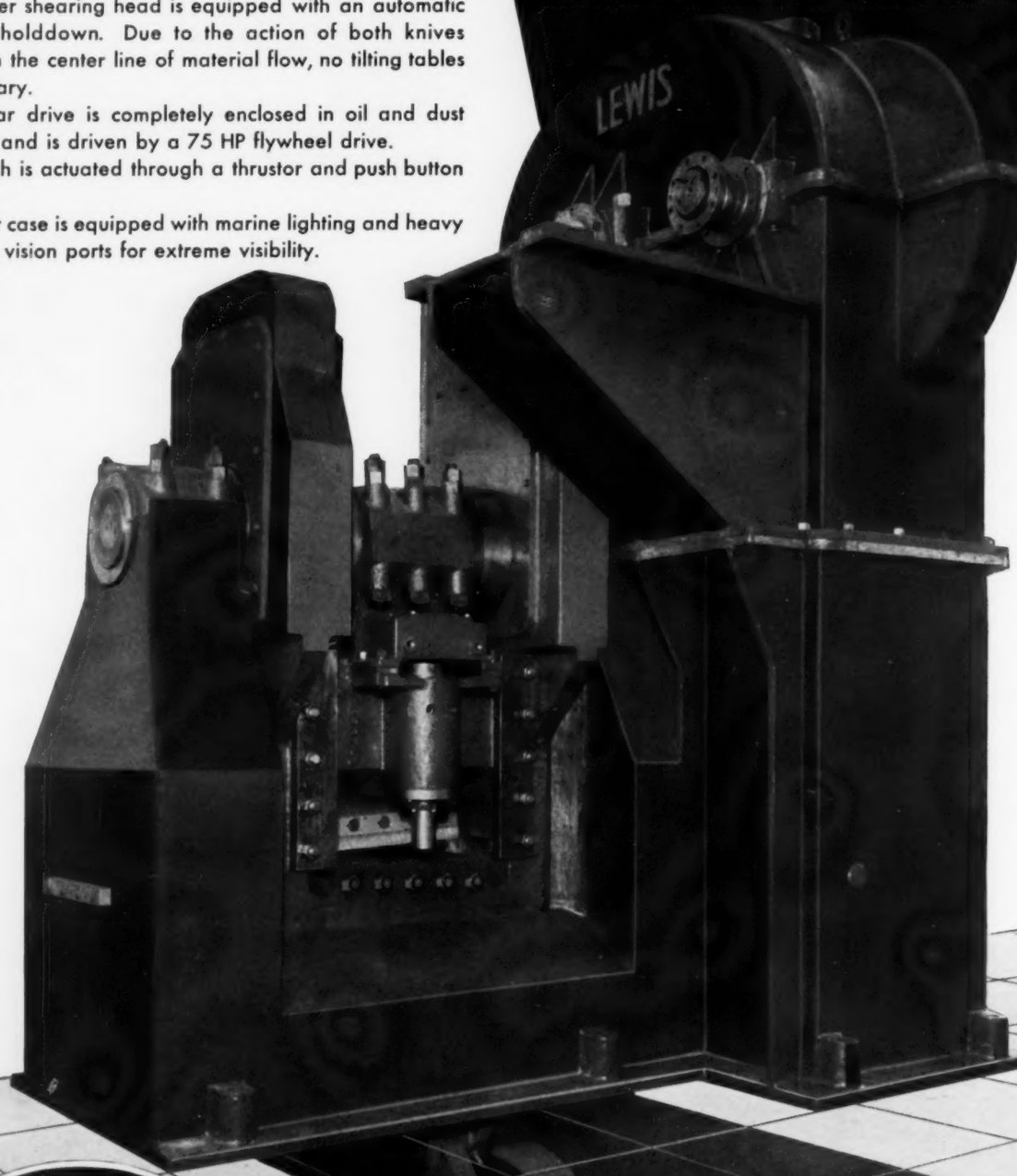
This shear is designed to crop 3" x 25" slabs. Both upper and lower knives function in vertical slides eliminating oscillation of the main cutting frame and assuring a true cut and straight slab after cropping.

The upper shearing head is equipped with an automatic hydraulic holddown. Due to the action of both knives meeting on the center line of material flow, no tilting tables are necessary.

The shear drive is completely enclosed in oil and dust tight cases and is driven by a 75 HP flywheel drive.

The clutch is actuated through a thrustor and push button control.

The gear case is equipped with marine lighting and heavy plate glass vision ports for extreme visibility.



LEWIS
Rolls and Rolling Mill Machinery step up tonnage

LEWIS FOUNDRY & MACHINE
DIVISION OF BLAW-KNOX CO.
PITTSBURGH, PA.

APPLICATION

Mfr. SCHLOEMANN ENG'G CORP.

Appli. SCALE TABLE "MOTOR-ROLLERS"

SKF Bearings and Pillow Blocks. An SKF Cylindrical Roller Bearing and a Spherical Roller Bearing inside each "Motor-Roller". A second SKF Spherical Roller Bearing in an SKF Pillow Block at live shaft outboard location.

The Plates Roll On . . .

Seven years ago SKF Bearings went to work on the Motor Rollers in each of two scale tables conveying plates ¾" thick x 90" wide x 60' long at 300 feet per minute. For seven years their rolling alignment has compensated for any and all developed warpage, deflection and misalignment. For seven years their high capacity has always been 100% available, and no adjustments have been required either in initial assembly or for wear. For seven years these compact and simply-designed bearings have been doing a firstrate job in helping these rollers keep Production UP. *And they're still going strong.* Another example why SKF's are the preferred bearings in the Steel Industry.

5219

SKF INDUSTRIES, INC., FRONT ST. & ERIE AVE., PHILA., PA.

ARMY E NAVY

SKF BALL AND ROLLER BEARINGS

OVERCOME THE SHORTAGE OF TIN BASE BABBITTS . . .

up to 100 times LONGER BEARING WEAR

with

Westinghouse MICARTA Roll Neck Bearings

Even *before* the WPB Order M-43-A cut the tin content of tin base babbitt to 12 per cent or less, Westinghouse Micarta outperformed ordinary bearings by as much as 100 to 1. Mill after mill has reported that Micarta stays on the job longer, rolls more tonnage with fewer shutdowns for replacements.

Micarta is the unusual bearing material developed by Westinghouse which combines resistance to pressure or pounding with an extremely low coefficient of friction. Its smooth. tough surface is self-polishing . . . and water-lubricated. Grease costs are eliminated. And Micarta's lower coefficient of friction is quickly reflected in substantial power savings. Runs with Micarta Roll Neck Bearings average about 200,000 tons!

On the basis of extensive experience in rolling mill applications, Westinghouse has engineered three grades of Micarta:

GRADE 271 (mineral-filled, fabric base)—A long-life bearing for high-speed, high-pressure work such as finishing stands.

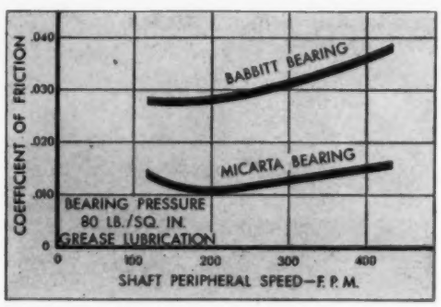
GRADE 295 (graphite-filled, fabric base)—Designed for slow-speed applications such as roughing stands, blooming, slabbing and structural mills.

GRADE 280 (heavy fabric base)—A bearing for broad scope of general applications.

Ask your Westinghouse Representative to show you some of the production records set by other mills using Westinghouse Micarta. Or write today to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., Dept. 7-N. J-06331

5 ways better . . . and available now!

1. **LOWER COEFFICIENT OF FRICTION**—The chart below shows comparison of Micarta with *pre-war* babbitt (85% tin).

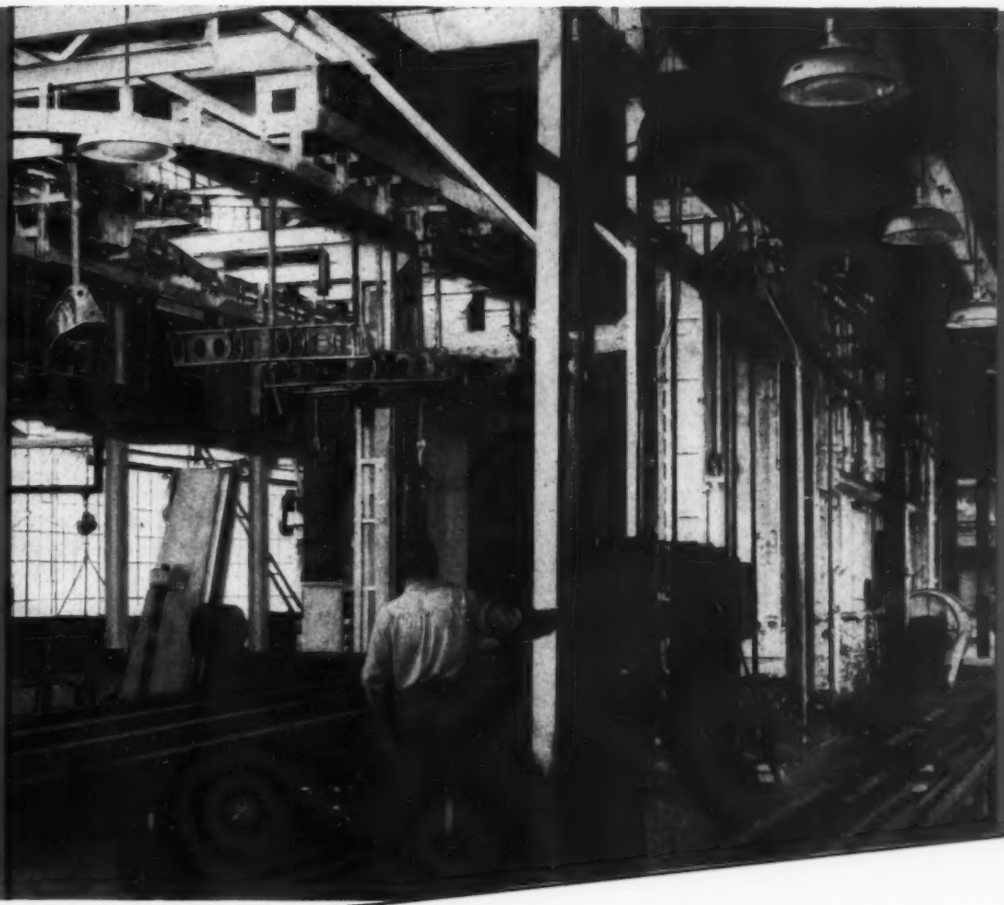


2. **25 to 50% POWER SAVINGS**—Due to lower peak kw demand and average kwhr consumption.
3. **GREASE COST NEGLIGIBLE**—Micarta is water-lubricated, saves grease labor and cost.
4. **LONGER ROLL LIFE**—No scoring of roll necks, no electrolytic action.
5. **CLOSER TOLERANCES OBTAINABLE**—Holds gauge accurately, requires fewer screw-down adjustments.

Westinghouse

MICARTA

Salem's Ingenuity Applies to Furnaces And Auxiliary Handling Equipment

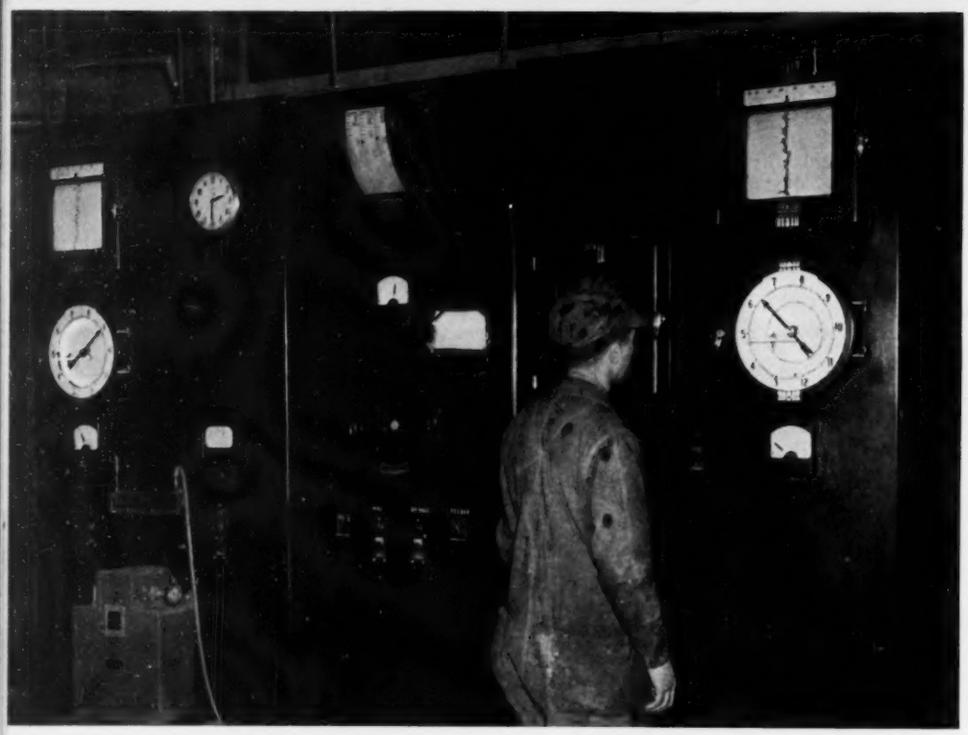


Example, Bomb Heat Treating and Handling is Now Only a 3 Man Job

The outstanding performance of Salem furnaces may well be attributed to Salem's experience and knowledge of plant production operations. Salem, therefore, builds and designs furnaces as well as auxiliary handling machinery, which co-ordinates the operations of all equipment to speed production and lower costs. With this thorough understanding of manufacturing procedure, Salem engineers can also offer dependable furnace designs which will dovetail into existing handling mechanisms. The bomb heat treating furnace, pictured above, gives evidence of Salem's complete engineering service. The furnace and quenching equipment, including conveyors, racks, charging and discharging apparatus, are all of Salem design. This war equipment . . . big and important as it is . . . requires only THREE MEN for operating as well as supervision. Write to Salem about your problem—use Salem's experience in war production equipment.

SALEM ENGINEERING COMPANY

SALEM ENGINEERING CO. . . SALEM, OHIO



Control panel for two rotary cement kilns, Federal Portland Cement Co., Bay View, N. Y. Each kiln uses strip-chart Micromax Rayotube Recorder for temperature of sintering zone, Micromax Round-Chart Recorder for discharge temperature, and L&N Furnace Pressure Controller. Gray, box-like instrument is Pressure Controller of an earlier design; instrument behind operator's head is latest design, pictured also at right.

KILN OPERATION HELPED 3 WAYS

By Use of Micromax Pyrometers and L&N Furnace Pressure Controllers

"Sure, we *could* run our kilns without instruments" say the workmen—and the managers—of Federal Portland Cement Co., "but here are some of the advantages we'd miss, which we now have with Micromax pyrometers and L&N Furnace-Pressure Controllers:"

1. The Pressure Controllers act as fast as the draft gauges move—therefore they hold pressure steadier than any man could hold it, because he would have to be guided by the gauges. Steadier pressure of course smooths out the temperature; means a better product in every way. And there is an indication of fuel saving.

2. The operator likes his job better when he has pressure controllers to help him; he is not only freed from the dull routine of keeping after the pressure, but can use his time to watch other details of operation. Taking care of L&N instruments doesn't require one one-hundredth of the work they save.

3. Micromax pyrometers not only help the operator, but their record charts prove to the boss that the kiln is being properly handled in his absence. A little experience has convinced both men and foremen that "Micromax Tells the Truth!"

L&N Furnace Pressure Controllers are described in Catalog N-01A-600; Micromax Rayotube Pyrometers in Catalog N-33B, and Micromax Thermocouple Pyrometers in Catalog N-33A. Any or all of these will be sent on request; if you require instrument-engineering service, we'll gladly supply it.

Quick Delivery Of Tubes For Thermocouples

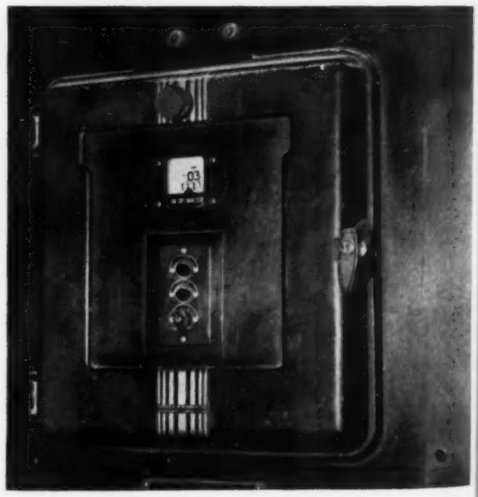
To help save metal in the present emergency, we can now supply tubes made of "Fyrestan" ceramic ware, to replace, wherever desirable, the iron, steel and alloy tubes which protect base-metal thermocouples. Fyrestan has long been our standard for temperatures too high for alloys, and we hope that its availability for use in the alloy range will now give many firms an opportunity to reduce the number of metal tubes they require.

An additional reason for adopting Fyrestan wherever possible is that it can usually be shipped much more promptly than metal tubes.

Fyrestan is of course not as strong as metal, but it is fully as gas-tight. Its life in service is comparable with that of metal, and in some instances, in the range 1800 to 2000 F, it should outlast an alloy. In general, it can be used for all applications except the following:

1. Immersion in molten metals
2. Immersion in certain molten salt baths
3. Where unsupported length exceeds 36" vertically or 18" horizontally
4. Where work in furnace may strike tube
5. Where tube is withdrawn frequently
6. Where furnace pressure is more than 1 lb per sq in.

When you need tubes, ask about Fyrestan. And if you have any of our "live" quotations, made before Fyrestan was available, we'll be glad to requote on the basis of Fyrestan.



L&N Furnace Pressure Controller corrects either big or small deviations with speed, accuracy and no hunting. Adaptable for any large industrial furnace; total range can be either 0.1 or 0.2 inches water. Moves the damper by means of electric-motor-drive unit.

Jrl Ad ENT-0600C(55)

LEEDS & NORTHRUP COMPANY, 4942 STENTON AVE., PHILA., PA.

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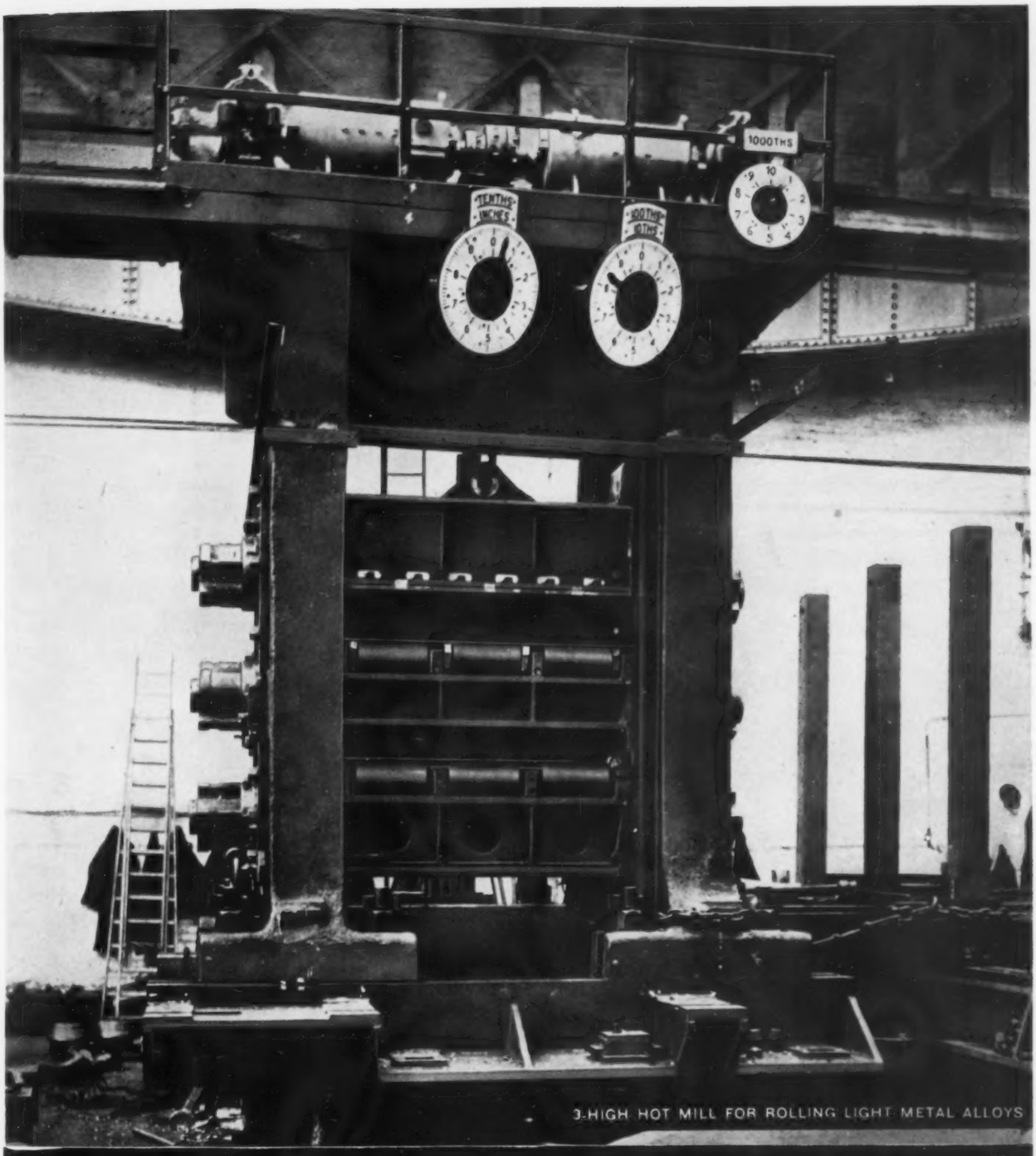
MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES



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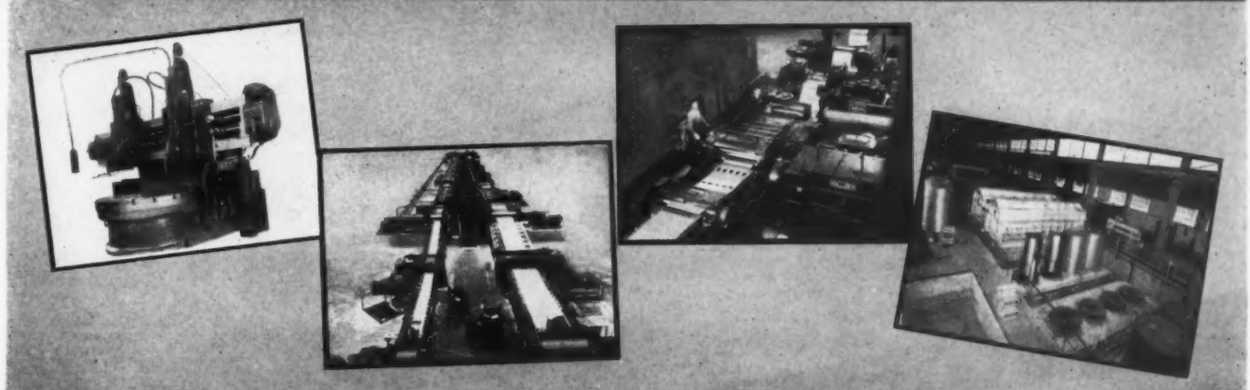

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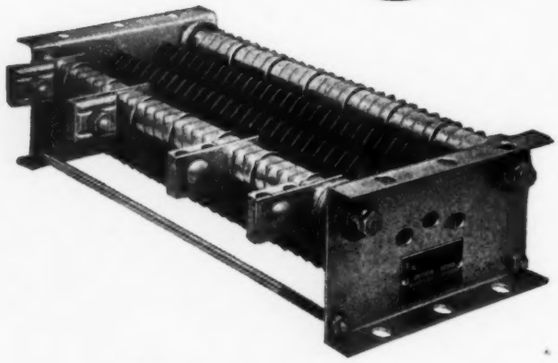

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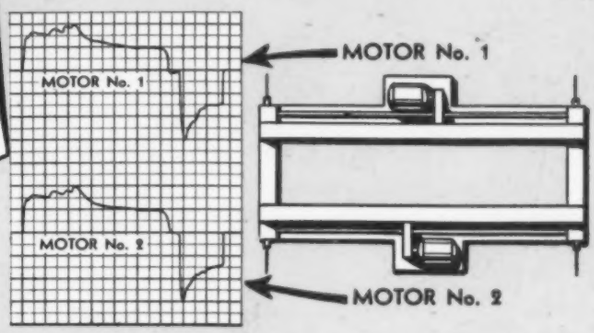

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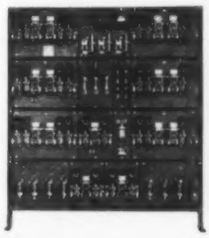

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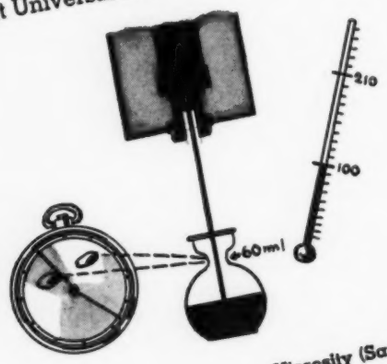

Examples	Viscosity (Saybolt Universal) at 100°F	at 210°F
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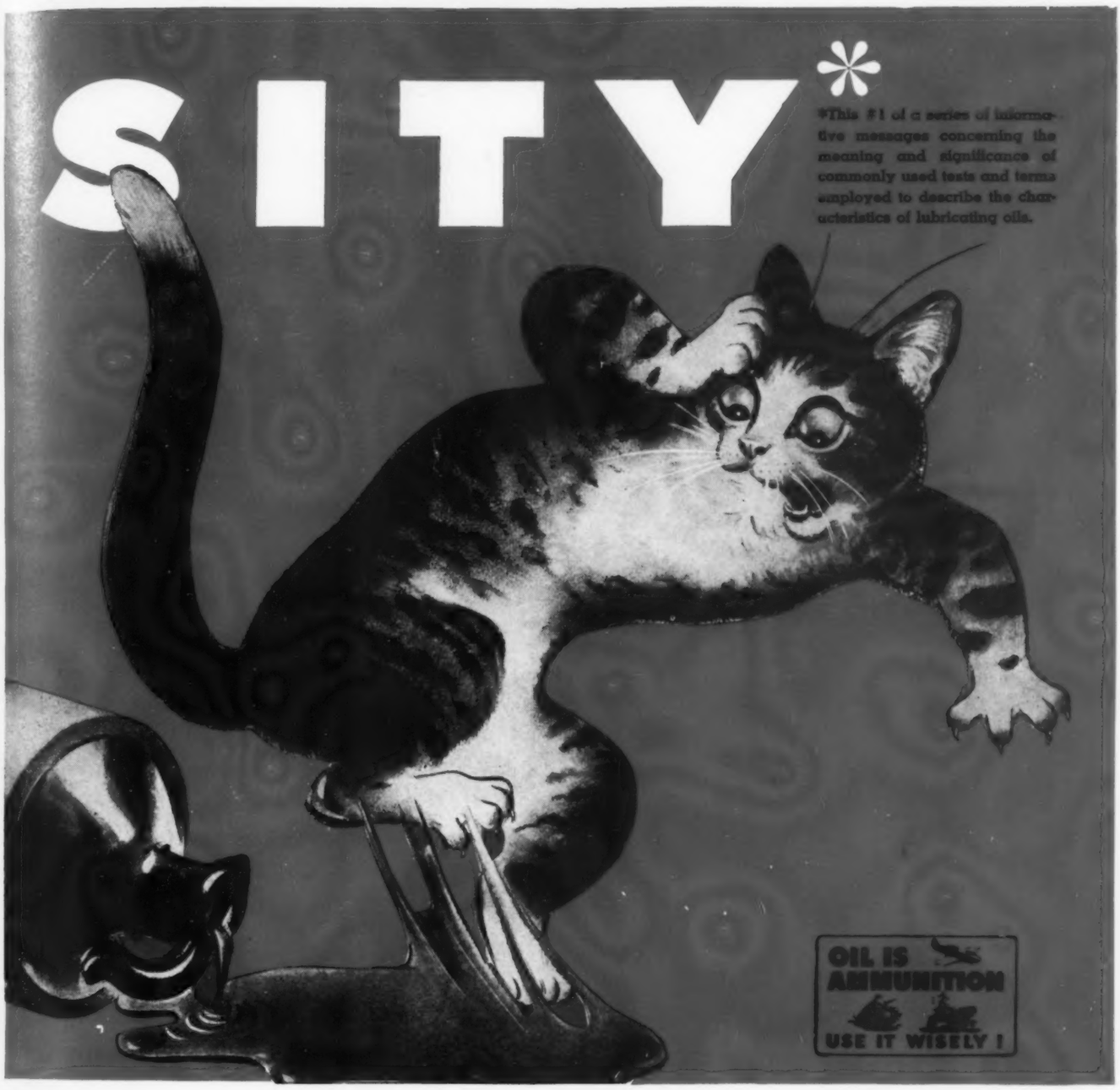
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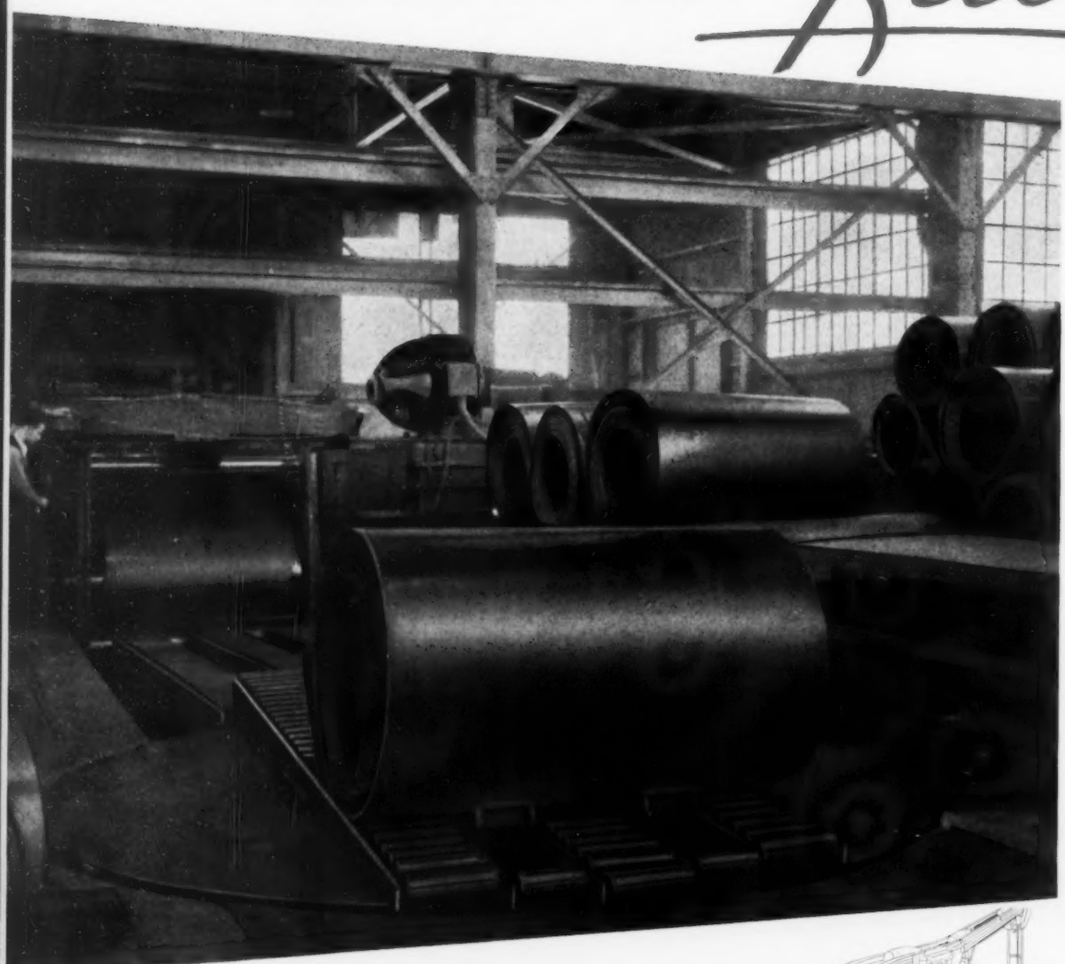

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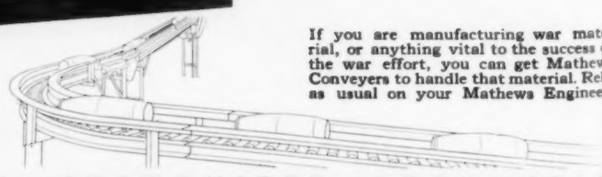

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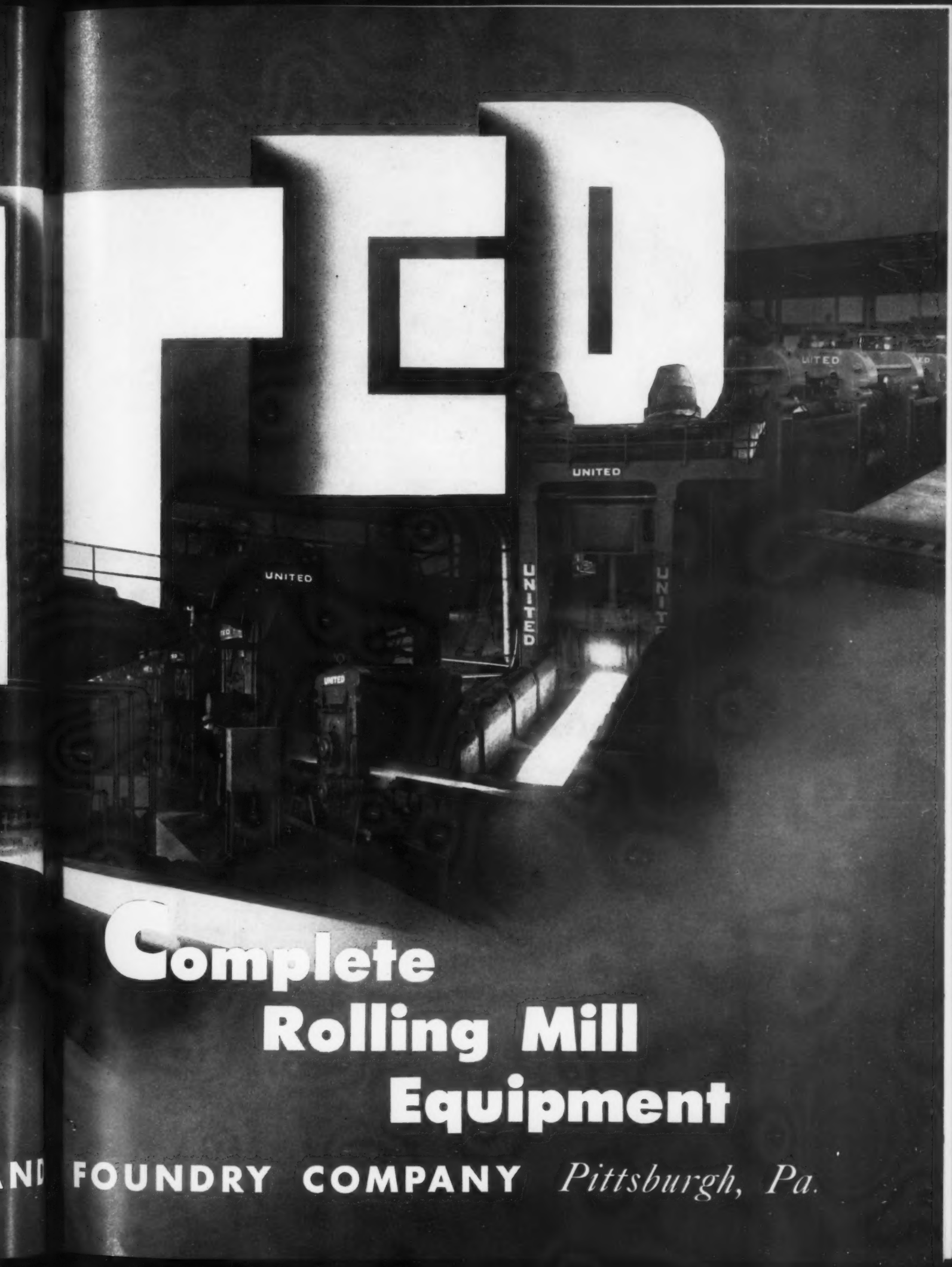

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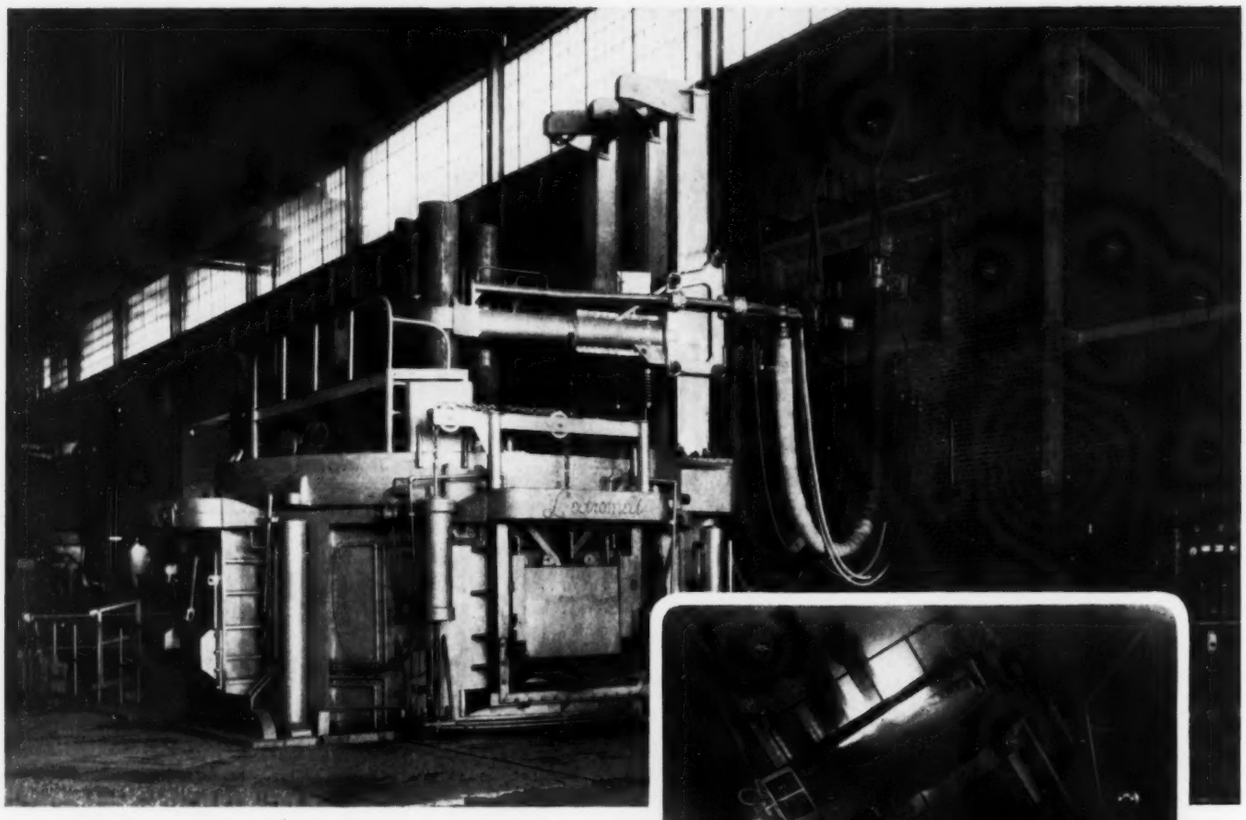

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The Furnace of Today and Tomorrow

MODERN *Cold Sawing* TECHNIQUE

. . . . studies of comparative cold sawing operations show a considerable margin of improvement obtained by new design developments . . . .

by **N. A. MALONE,** Plant Industrial Engineer
Timken Roller Bearing Company
Steel and Tube Division, Canton, Ohio

▲ THE purpose of this paper is to present and describe to industry an efficient and economical method of cold sawing steels vital to the manufacturing of materials for the war effort.

The increased demand for quality steel (stainless and other high alloys) and the present rigidity of metallurgical inspection and requirements have made it necessary to furnish large quantities of cold sawed metallurgical test samples for the determination of quality.

This accelerated demand for test cutting beyond normal requirements had become too great for the existing cold sawing equipment, much of which had been made obsolete through inadequacy to cope with this burden.

With this problem in mind, in May, 1939, a detailed study was started of data relative to ways and means of improving the productivity of cold sawing equipment and finding better technique of operation.

The first series of studies revealed that performance and efficiency of existing cold sawing equipment were rather limited because machine design provided too limited selection of feeds and speeds and was inadequate to provide maximum cutting efficiency and output.

Relative to this problem, extensive experiments were conducted for improving the cutting performance of the saw blades themselves. As a result of these studies, the curved gullet tooth form (Figure 1) was developed for the application of cold sawing various grades of alloy steels.

Based on past performance, production of cold saw machines was increased on an average of thirty per cent, due to the curved gullet tooth form.

Table I represents cold sawing performance from different makes of machines when employing this type of tooth form.

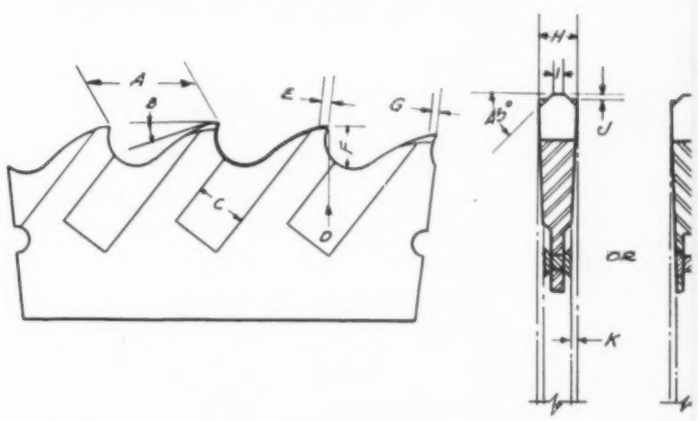
Presented before A. I. S. E. ANNUAL CONVENTION, Pittsburgh, Pa., September 22 - 24, 1942

By the analysis of the progress made in cold sawing equipment and methods, it was clearly indicated that efficient and low cost sawing was dependent upon the adoption of:

1. Hydraulic and high speed sawing equipment.
2. Segmental type circular saw blades with curved tooth form.
3. Automatic saw sharpener.
4. Definite tailored technique — or, selecting procedures according to types of steel.

It was early suspected that the factors of older mech-

Figure 1 — Curved gullet tooth form.



A = Pitch
B = Clearance Angle
C = Coolant Channel
D = Rake
E = Follow Tooth Land
F = Depth 40% of Pitch
G = Guide Tooth Land
H = Follow Tooth
I = Guide Tooth
J = Height Difference
K = Side Clearance

anical design had a direct bearing on the efficiency. This led to comparative study of mechanical vs. hydraulic applications.

For reasons familiar to all, the use of hydraulic rather than mechanical design seemed logical in the search for more selective control and general flexibility of operation. Foreign makers led in the early stages of this development and their product for a time was superior to those of domestic design.

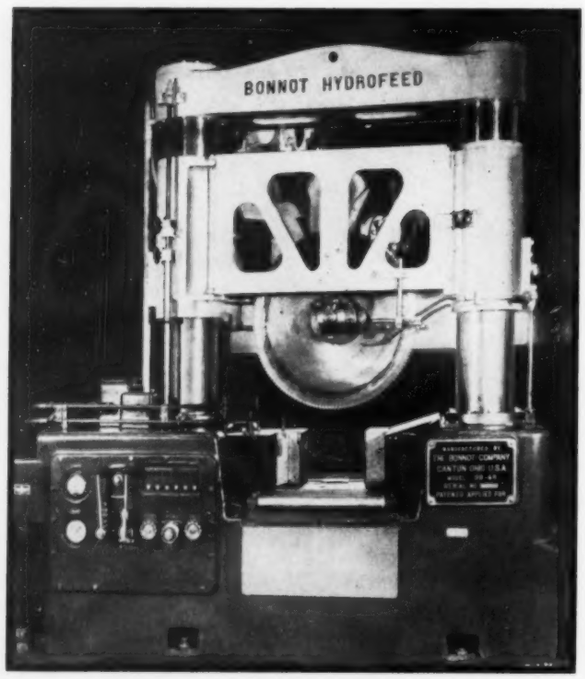
America accepted their challenge. Improvements were made all along the line. One unit of American design and manufacture was developed to embody the outstanding features of the best foreign saw and also included additional elements of important value not found in such unit. (Figure 2) This saw incorporates the necessary features of variable feeds and speeds for rapid, economical and accurate cutting of all grades and sections of steels that fall within the range of given blade size and type.

GENERAL MACHINE EXPLANATION AND ITS FUNCTIONS

Construction — The saw was designed and constructed as a single unit embodying all electric, hydraulic and mechanical equipment required for complete operation.

The machine base, guide columns and column crosshead were assembled to form a closed and oblong frame in which the saw carriage moves up and down. The construction of this frame is exceptionally heavy and is sufficiently rigid to assure the smooth and chatter-free performance which is necessary for rapid and heavy cutting. It is to be noted that stresses which are created by uniform and down-feed sawing are confined within this rigid frame and are transferred as resultant forces to the massive base, all indicated by arrows on Figure 3, which shows the front elevation of the assembled saw.

Figure 2 — This saw was developed for rapid, accurate, economical cutting of all grades and sections of steels falling within the range of a given saw blade.



Method of operation — The operation of the saw is based upon the down cut and controlled feed principle, and all movements of its carriage, as well as its material-clamping vise, are performed hydraulically, while the saw blade which rotates on the saw carriage is driven electrically. These major functions are brought about in a manner which insures maximum convenience and safety for the operator and protection to the entire unit.

Cutting cycle — The following functions constitute the cycle of operations for the saw and are essential to efficient cutting and complete control:

1. The saw carriage has a maximum vertical travel of 26 inches.
2. The saw carriage can be manually adjusted for any required length of travel within the range of maximum travel.
3. The adjusted length travel for the saw carriage can be manually changed to operate at any position within the range of maximum travel.
4. The saw carriage can be manually started or stopped and reversed at any point within its adjusted downward or upward travel
5. The speed of the down travel of the saw carriage from relative top position to that of close proximity to the material to be cut is rapid and is accomplished by the operator when manually holding the carriage control lever in the rapid down position. When the operator releases his hold upon this lever, the speed of travel of the saw carriage is immediately and automatically changed from rapid to controlled down travel.
6. The rate of controlled down travel of the saw carriage is constant for any desired feed and continues downward at the set rate until material is completely cut and the carriage reaches its relative bottom position.
7. At the end of the controlled down travel, the saw carriage automatically reverses its direction of travel and starts upward at a rapid rate which continues until it reaches its relative top position where it automatically stops and remains until the cycle is repeated.

Hydraulic system — The hydraulic system employed for the operation of the saw carriage and clamping vise is an exclusive development for this machine and furnishes power for all movements of the saw carriage and vise.

This system operates with low pressure which eliminates leakages, is flexible, and lends itself to immediate adjustment for any desired requirements. It is also designed so that each part is independent and is easily replaced, repaired and adjusted.

COLD SAWING PERFORMANCE

Experience with this new cold saw has definitely proven that there have been few performances in cold sawing so worthwhile or rapid as with this method. It is noted by Table II that performance and efficiency

were considerably improved over the former practice as shown in Table I.

To elaborate on the performance of this saw, a comparison of cutting efficiency between Table I and Table II by type of steels is listed (Table III).

SEGMENTAL TYPE CIRCULAR SAW BLADE

Since the saw embodies a specific method for bringing the saw blade into controlled contact with the work, it thus enables the blade to cut the work with the best possible degree of efficiency. Further, the performance of any saw, regardless of how carefully designed or constructed it may be, is of course limited by the capability of the saw blade.

Blade design and quality, however, have so rapidly been improved as to call for the machine design and construction not required for earlier slow speed cutting methods. Both basic elements had to be balanced for maximum results.

The factors which govern the successful performance of a saw blade are as follows:

1. Determination and application of pitch and tooth form in relationship to hardness and section of material to be cut.

Up to date, manufactures of modern cold saw blades have not been able to give the consumer a steadfast rule in the selection of blades since their experience has been limited more or less to the laboratory. However, their progress depends on the various experiments made by the customers who are faced with the problem of cutting a wide variety of analyses and sizes of steel.

Since our company has had the job of cutting a range of 350 analyses, we had a fertile field in which we could experiment. With the advantages of modern high speed

TABLE I

Make (1)	Sq in. cut (2)	Gross time, minutes (3)	Sq in. per minute (4)	No. of cuts (5)	Time per cut, minutes (6)	Cost per cut (7)
A	27,932	34,560	.81	436	79	$1.22
B	35,610	42,140	.85	556	76	1.17
C	40,754	32,325	1.26	637	51	.79
D	31,302	25,350	1.23	489	52	.80

NOTE: For comparative purposes, number of cuts (column 5) was adjusted by assuming an average of 64 sq in. per cut.
Gross time (column 3) represents total cycle time — handling and cutting.

TABLE II

Make (1)	Sq in. cut (2)	Gross time, minutes (3)	Sq in. per minute (4)	No. of cuts (5)	Time per cut, minutes (6)	Cost per cut (7)
A	27,932	34,560	.81	436	79	$1.22
B	35,610	42,140	.85	556	76	1.17
C	40,754	32,325	1.26	637	51	.79
D	31,302	25,350	1.23	489	52	.80
E	298,350	63,210	4.72	4661	14	.22

TABLE III

	New	Previous
Carbon steels	5.83 sq in. per min	1.53 sq in. per min
Nickel	2.39 sq in. per min	1.72 sq in. per min
Nickel-chromium	2.45 sq in. per min	1.59 sq in. per min
Chromium-molybdenum	4.65 sq in. per min	1.48 sq in. per min
Nickel-molybdenum	4.16 sq in. per min	2.03 sq in. per min

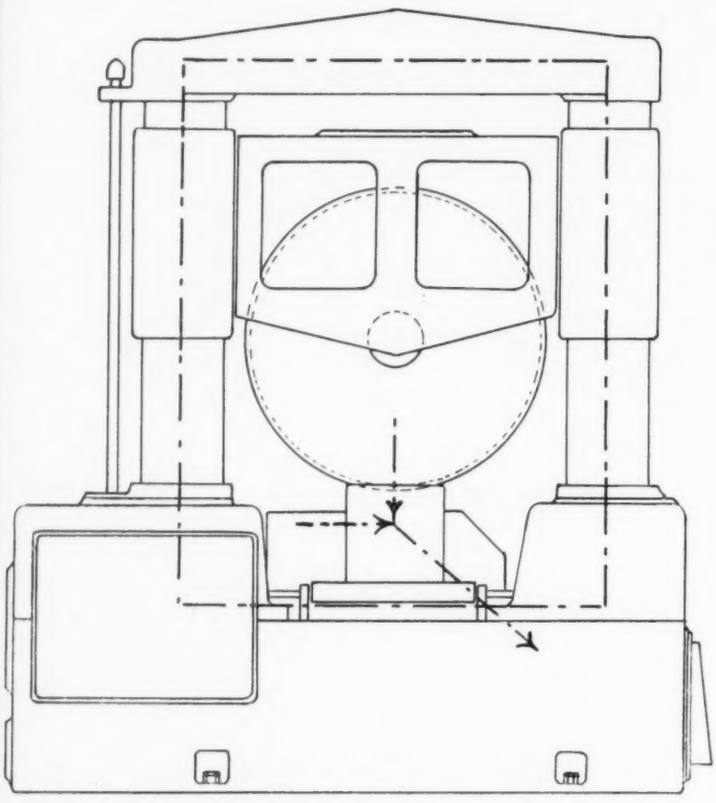


Figure 3 — Sketch showing resultant of stresses set up by down-feed sawing.

cold sawing equipment we were able to formulate a general theory which applied to the selection of a blade, namely:

The lower the Brinell hardness, the greater the pitch; the higher the Brinell hardness, the finer the pitch.

Inasmuch as it is impractical to have a large selection of blades for the various cutting, we limited ourselves to establish three types of all-purpose blades. (See Table IV.)

In the analysis of these selections, it is to be noted that the pitch and angle of tooth (columns 3 and 4) are fairly distributed to compensate for the thickness of chip which forms in the gullet of the tooth by free cutting action. This, of course, is controlled by feed and size of material. The heavier the feed, the more chips each tooth is confronted with; consequently, the necessity for a wider pitch. The larger the size of the cut to be made, the greater amount of chips each tooth has to carry through and there must be enough gullet space to curl and carry the chips through, thus kicking itself out of the gullet and clearing the tooth completely for its succeeding cut.

The free cutting action of the curved tooth is not entirely due to its shape; the technique of grinding is an essential factor in its performance. In grinding the teeth of a blade, every other tooth is .012 in., .018 in. or .025 in. (column 6) higher and is beveled at 45 degrees on both sides so that the width is one-third of the follow tooth which has a square face and is the actual kerf of the blade. The high tooth, namely the lead tooth, cuts a center groove in the material and the follow tooth cuts two narrow chips at the sides to complete the width of the cut, thus breaking the chip into three parts.

The requirements established by the above selections and grinding are as follows:

Material cut between regrinds..... 12,050 sq in.
Material cut per life of segments.....274,000 sq in.
Capability to cut, maximum square inches per minute..... 25.6 sq in.

THE AUTOMATIC SAW SHARPENER

In the foregoing paragraphs, we have endeavored to present the outstanding development and performance of the cold saw and blades. However, due consideration should be given to the aggressive designer of the automatic saw sharpener (See Figure 4). Without his aid the stated development of cold sawing would have been impossible.

The versatility of this sharpener enables the operator to provide with ease any specification of grinding as desired by the cold saw operator. In the design of the machine the construction has been made as simple and direct acting as possible to facilitate quick action in adjustment of various angle requirements of the saw blade.

Respective index plates are employed with the various pitches to insure uniform feeding and grinding of the blade teeth and will not be subject to any irregularity from any uneven, worn, or broken condition of the teeth to be ground.

The grinding action of the machine is based on the

TABLE IV

Type of steel (1)	Brinell hardness (2)	Pitch of saw tooth (3)	Rake angle of tooth, degrees (4)	Peripheral clearance of tooth, degrees (5)	Height difference of tooth, in. (6)
Mild	Up to 200	.98 in., 120 teeth	24	11	.025
Medium	200 to 250	.79 in., 150 teeth	18	9	.018
Hard	250 to 300	.65 in., 180 teeth	12	7	.012

form grinding method, using a grinding wheel which, when dressed, will conform with the radius of the gullet of the tooth. The tooth shaping and grinding mechanisms are adjusted so the grinding wheel follows the contour of the teeth as each tooth is fed past the grinding wheel, thus sharpening the teeth from the point down the body of the tooth, giving clearance and strong backing to the tooth point or land. The teeth must be ground uniformly and the points kept perfectly in spacing so that the strains on the blade are equalized.

Upon completion of all the necessary adjustments, the grinding work will be done entirely automatically with no attention from the operator from the time the saw blade is placed on the machine until is its ready for sawing service, other than an occasional turn of the hand wheel to adjust for tooth shape or compensate for grinding wheel wear.

In our work of improving cold sawing efficiency, we found that the automatic sharpener was practically indispensable in obtaining the knowledge on the application of cold sawing technique.

TYPES OF STEEL

As advance by well known authors, machinability of various types of steel has been covered by a multitude of theories. Inasmuch as this paper does not wish to contribute additional complexities to the subject, we will isolate the subject to the technique of cold sawing. Hereafter, machinability will be referred to as the sawability of steels.

The cutting operation of cold sawing with the circular blade is in a class by itself and has several advantages over other methods of cutting steels, which are as follows:

1. Capacity
   a. Wide range of sizes, weight, and shapes.
2. Tool life.
   a. The intermittent nature of the cut, allowing the teeth or blade to cool between contact time of the tooth during each revolution.
3. Designed for one operation, that of cutting off steel.
4. Efficiency.
   a. Economy and speed.

In cold sawing various steels, experience has indicated that Brinell hardness (average Brinell hardness across cut section) and size of section for certain steels, regardless of how hardness was produced, can be used as a measure of sawability. A general rule in the application of feeds and speeds which was observed in obtaining the performance as noted in Table II is as follows:

1. The smaller the size of the section, the higher surface feet per minute.
2. The lower the Brinell hardness, the heavier feed in inches per minute.

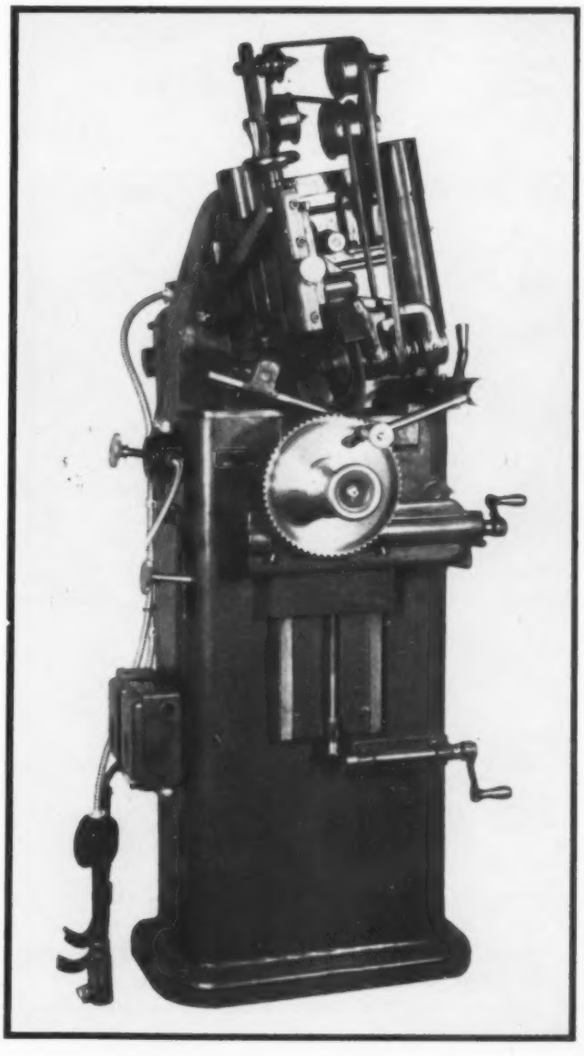
However, the variations in different plants, not only in respect to equipment, but also to the material worked upon, preclude either the data given in Figure 5, or some method by which feeds and speeds can be determined. The feeds and speeds here illustrated are based on experience and have been in satisfactory use as a basis for cold sawing in our plant. In another plant the conditions might be quite different and a different set of standard feeds and speeds might be necessary.

One of the important aspects of a program of maximum production, therefore, is a careful investigation into the nature of the material to be cut and the establishment of a set of standard feeds and speeds in relation to the variants, namely: The quality of the metal being cut, size of the section, and the selection of the saw blade, with the assumption that the work is to be done on a modern hydraulic feed cold saw machine.

CONCLUSION

Since the successful performance of a machine tool depends upon the capability of the operator, attention should be given to the establishment of a standard practice of operation. Based on general observations of

Figure 4 — The automatic saw sharpening machine enables the operator to produce with ease any desired grinding specification.



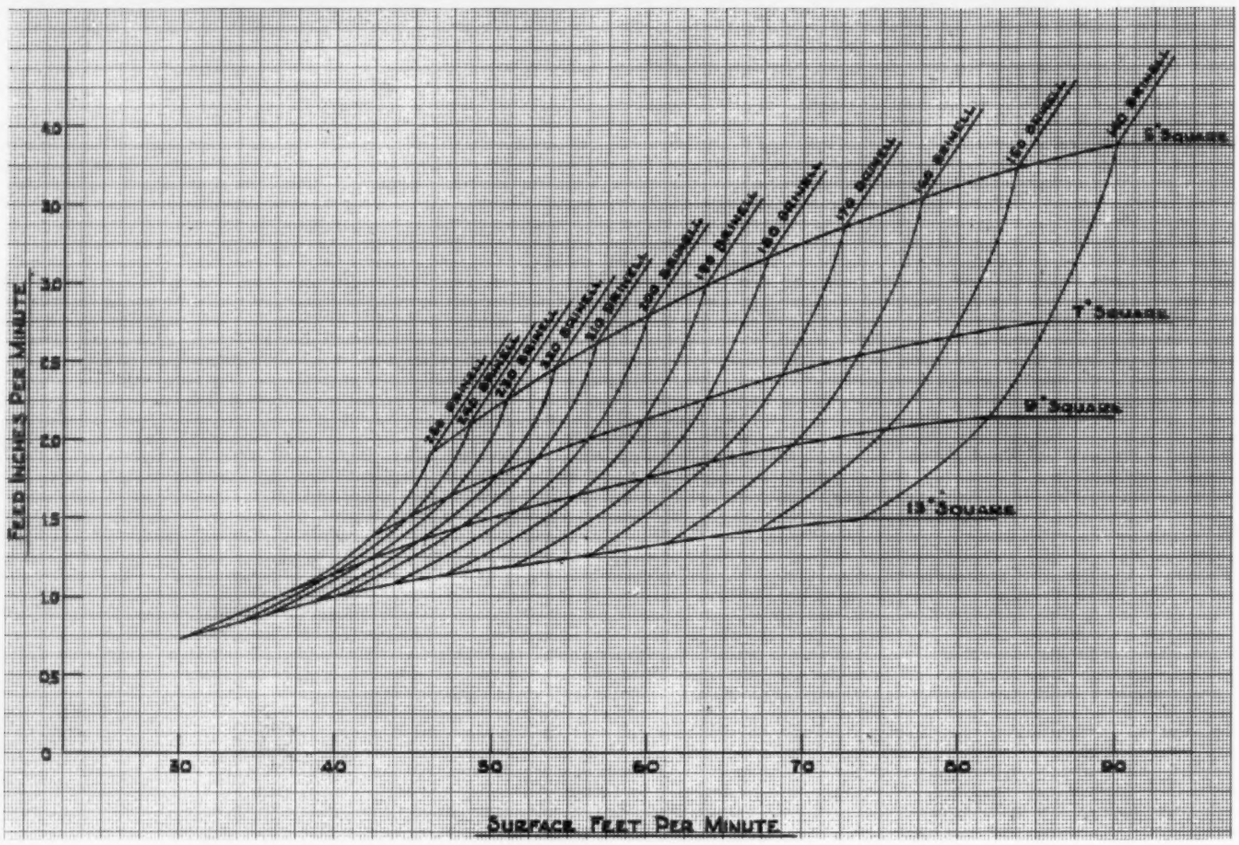


Figure 5 — Chart showing feeds and speeds developed in one plant for various sizes and hardness of material.

our cold sawing experience, the following set of rules was established:

1. The saw blade requires constant inspection. Keep the saw sharp and avoid running it dull. Do not wait until the teeth are round and worn down.
2. The sharpness of the saw blade will not make amends for badly shaped teeth. Always maintain their original shape and bevel.
3. Keep teeth uniform in height and do not use a blade that appears out of round.
4. Forcing a saw blade is bound to strain it and may result in broken teeth or a dished blade.
5. Be sure there is a continuous stream of coolant on the teeth before the saw enters the cut.
6. When blue chips are appearing, slow down the speed and feed.
7. Successful cold sawing is dependent on the proper application of feeds and speeds. Hogging or pushing the metal is not cutting and blued or colored chips are not indicative of good cutting and proper cooling.
8. It is the operator's responsibility to see that the machine is operating properly and he should demand immediate millwright service if the machine does not seem to function properly.
9. Under no circumstances should the operator attempt to make repairs or adjustments to the machine other than the necessary operating adjustment.
10. Inspect machine periodically and prevent it from getting in poor running condition. A good saw blade can not do good work on a poor machine.

DISCUSSION

PRESENTED BY

ALEX MONTGOMERY, JR., Carnegie-Illinois Steel Corporation, Duquesne Works, Duquesne, Pennsylvania

N. A. MALONE, Industrial Engineer, The Timken Roller Bearing Company, Steel and Tube Division, Canton, Ohio

L. F. COFFIN, Superintendent Mechanical Department, Bethlehem Steel Company, Sparrows Point, Maryland

G. W. BROWN, Metal Saw Engineer, Simonds Saw and Steel Company, Fitchburg, Massachusetts

ALEX MONTGOMERY, JR.: I would like to ask Mr. Malone a question. He mentioned the hardness of the steel as 140 to 150 Brinell. You mean 140 to 250?

N. A. MALONE: I referred to the range of Brinell hardness on the chart as 140 to 250. However, 250 is not the highest hardness, since we have been successful in cold sawing nitralloy steels with 426 Brinell on our saw.

ALEX MONTGOMERY, JR.: I want to ask the experience on much harder steels up to 400. Is reduced feed and speed necessary?

N. A. MALONE: Yes, in cutting extremely hard alloys, specific cases have indicated that the theory most suitable in cutting hard alloys was the application of a high surface feet per minute and a light feed, which is a principle the carboloy tip tool people are so successful with, in other words, a light chip and a high surface feet per minute.

C. J. DUBY: In the increase of number of square inches to be cut, do you do anything with the coolant, the cutting compound?

N. A. MALONE: Yes, increase the volume of flow. The ratio of compound we use is 15:1. The primary function of the fluid as used in cold sawing is a cooling and not a lubricating agent, due to the free curling of the chips and the intermittent nature of the cut, allowing the teeth or blade to cool between contact time of the tooth during each revolution of the saw blade. This is one of the chief factors why we have established such a tremendous life on saw blades.

L. F. COFFIN: I believe you showed a cost of $ .20 per cut. How many square inches per cut? That wasn't clear.

N. A. MALONE: For comparative cost purposes, number of cuts was adjusted by assuming an average of 64 sq in. per cut, or an 8 x 8 bloom.

L. F. COFFIN: Twenty cents?

N. A. MALONE: No, twenty-two cents; only the cost of labor was considered. Overhead is not involved.

L. F. COFFIN: What material did you use in your cutters?

N. A. MALONE: The tooth segments are made out of 18-4-1 namely: High speed steel and heat treated to 63 Rockwell C hardness. The saw bodies are ¼ inch .90 carbon alloy plate, and of course the thickness of your segment gives you the proper side clearance of $\frac{1}{32}$ of an inch on each side. It is an established fact, that without this clearance you will create jamming of the teeth and the tearing of chips.

In trying to explain the stated "three component parts of the chip," I mentioned the middle section, which is the width of the lead tooth or beveled tooth, and is curled like a clock spring. If properly annealed and stretched out, it should be 3 or 4 inches long. Then we have the side sections which are cut by the wide or follow tooth. In other words, we have two narrow and one wide chip. It should be noted that these chips are fairly heavy in thickness. They are clean and not made blue by over-feed, which represents a good indication that good performance is being obtained by expelling chips like clock springs, and they fly out every time the tooth leaves the cut.

G. W. BROWN: I have always found the harder the material, the slower the saw speed should be, thus preventing excessive dulling of the cutting teeth. You made a statement that a high surface speed should be used with a light feed.

N. A. MALONE: That is right, with the present type of modern equipment. Before I elaborate on this theory, I would like to say that Mr. Brown has collaborated with me on the recent development of a blade that will vouch for statements made in the success of modern cold sawing. That is one reason why the high surface feet has been so successful in this method.

Referring to your findings, I assume that you have in mind the use of the old type single insert tooth blade on mechanical feed machines, where the feeds and speeds are synchronized. With this method, I agreed with your principle; however the new theory has been based on the new designed saw machine. which has independent selection of 1 to 20 inches feed and 8 various saw speeds that range from 25 to 128 surface feet per minute.

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USE "Multicut" shear knives and slitters for greater tonnage.
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PROPERTIES of Blast Furnace Cokes

. . . . an examination of factors entering into coke quality shows that usual procedures of testing coke do not provide adequate control of the important structural properties . . . .

by H. H. LOWRY and M. A. MAYERS

COAL RESEARCH LABORATORY

CARNEGIE INSTITUTE OF TECHNOLOGY

PITTSBURGH, PENNSYLVANIA

▲ COKE, for use in blast furnaces, is generally supposed to have certain definite physical and chemical properties, which determine whether or not the blast furnace operation will be satisfactory. It is known, however, that pig iron is made successfully in American practice with cokes ranging in ash from 5 to 12 per cent, in sulphur from 0.5 to 1.8 per cent, in porosity from 40 to 60 per cent, and in 2 in. shatter index from 10 to 75 per cent; while the range in mean size as charged covers a ratio of 3 to 1, and the range of specific reaction rates to oxygen at 930 F covers a ratio of 30 to 1. Nevertheless, changes in the qualities of the coke at a given blast furnace, which are small relative to these ranges, are frequently blamed for unsatisfactory operation.

The reason for these extreme ranges in coke quality is to be sought in the fact that these properties depend on the coal available — available at a cost consistent with profitable operation, — and on coke oven practice. The limiting factor in control of the qualities of coke made from a given coal is that changes in coke oven practice can only partly compensate for changes in coal quality.

It is obvious that the properties of coke supplied to any one blast furnace plant could not be permitted to vary over the extreme ranges given above. Estimates have been published, however, of the value of small increments in certain properties of cokes, based on observations at single plants. While the relative costs of operation of plants using cokes of extreme properties are not available, it is doubtful if the differences in economy are as great as would be indicated by these estimates, since the ingenuity of blast furnace operators has enabled them to change practice to suit local conditions. This ability, however, cannot be exercised for short-time fluctuations in quality level because, if for no other reason, the fluctuation cannot be assessed in time to make the correct adjustments. Thus, satisfactory operation is greatly dependent upon uniformity of quality.

Coke is supplied to the blast furnace as a broken solid, which is bedded to form a structure carrying the burden. This composite column moves down through the furnace, the materials of the burden undergoing reaction, while the coke-supporting structure is only slightly attacked. When most of the burden in an element of volume has melted as iron and slag, the remaining coke reaches the tuyere zone and is burned. The burning supplies essential heat, which is transported by the flowing gas to the higher levels at which the reactions occur. This transport depends on the permeability of the stock column which, in turn, is determined by the size, shape, and distribution of the channels within the stock column. Hence, the first point of interest is in the structure formed by the bedded coke; this is primarily determined by its particle size.

Presented before A. I. S. E. ANNUAL CONVENTION, Pittsburgh, Pa., Sept. 22-24, 1942

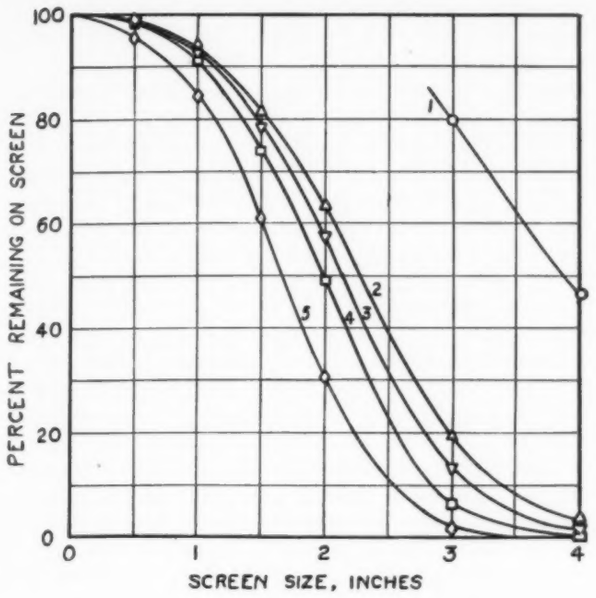

Figure 1 — Screen analyses of coke leaving the oven (curve 1); at cross belt from the coke oven after a 7.5-foot drop (curve 2); at bunker belt No. 3 after a total drop of 25.5 feet (curve 3); at bunker belt No. 1 after a total drop of 38.5 feet (curve 4); and in bunker No. 1 after a total drop of 48.5 to 58.5 feet (curve 5). Data from Mott and Wheeler. (1)

SIZE

The size of coke in the stock column depends both on the initial size of the coke and on its size stability. These quantities are not independent; the size after the shatter test is significantly, but not closely, related to the initial size of the coke, as would be expected. The initial size of coke is not adequately described by any single parameter, such as the mean size or the percentage on any particular screen such as the 2 in. A screen analysis is necessary, which, as ordinarily reported, may be shown graphically as in Figure 1. These data represent screen analyses of a coke at various points in its travel from the coke oven to the blast furnace.[1] The mean size of the coke can be estimated from Figure 1, but this method of plotting does not permit an easy estimate of the other characteristics of the size distribution. When, however, these data are plotted on probability paper, as shown in Figure 2, the distributions fall on straight lines from which the mean size, M, and another quantity, defining the breadth of the distribution, can easily be read. Several such quantities might be chosen; a simple one which has been used is R, the "spread," defined as the difference between the mean size and the size at either 25 or 75 per cent passing or on. In this method of plotting, all of the data contribute to the accuracy of determination of the size criteria, M and R; a faulty estimate because of a single erroneous entry in the screen analysis is, therefore, less likely to occur.

These two values, M and R, completely describe the distribution when the size analysis yields a straight line on probability paper. This is generally true for blast furnace coke. A further advantage of this method of expressing screen analyses is that its accuracy does not depend on maintenance of arbitrary screen openings provided that the actual size of the openings is known. For instance, the point on curve 1 of Figure 2 at nominal 3 in. size would fall exactly on the line if the screen opening as used was $3\frac{1}{16}$ in. Moreover, if after a screen analysis is made it is discovered that the screen openings were different from the nominal size, the result of the analysis would be useless for reporting a specific size index. If, however, the actual sizes of the openings are measured, and the data plotted on probability paper, the mean size and spread can be determined quite accurately from "off-size" screens.

The size and size distribution of the bed of coke determine, to a great extent, its resistance to the flow of gas. In the stock column, however, this resistance is even more greatly influenced by the size and size distribution of the burden since the quantities affecting gas flow are the characteristics of the total charge. The resistance to gas flow increases rapidly with a decrease of particle size, varying inversely as M^2, the square of the mean size at low rates of flow[2] and with a somewhat smaller exponent at high rates such as prevail in the blast furnace. The resistance also increases with increasing spread,[2] but the exact dependence is not yet known for the types of size distribution found in the blast furnace.

The reason, therefore, for controlling size and size distribution of blast furnace coke is to control the volume of voids among the pieces of coke. It is this void volume which actually carries the burden, spreads it out for reaction with the gas, and prevents the high resistance layers of ore and stone from completely blocking passage of gas. The void volume of a bed is increased by uniformity of size of its constituent particles, by irregularity in their shapes, and by roughness of their surfaces, and it is independent of the absolute magnitude of their size. It follows that, in the past, too much attention may have been paid to M, the mean coke size, while little or no consideration has been given to the variable, R, the spread in size. The latter should be at a minimum to produce a bed of high void volume; and this is the primary reason for emphasis on close sizing of coke. The significance of the size and size distribution of the coke in determining the void volume of the bed was considered in more detail in a previous paper;[3] much more experimental work remains to be done before the dependence of gas flow properties on these quantities is thoroughly understood.

Unquestionably coal quality, the density of the coal charge, its fineness of grinding and uniformity of blending, and the final coke temperature — not, be it noted, the flue temperature — influence coke size. There is not sufficient published information on the effect of these quantities on the size of coke from commercial ovens under controlled conditions to permit an evaluation of their separate effects. However, the U. S. Bureau of Mines has carbonized 83 coals and blends in a circular retort 18 in. in diameter and and holding 170-210 pounds of coal crushed to pass $\frac{1}{4}$ in. mesh screens.[4]

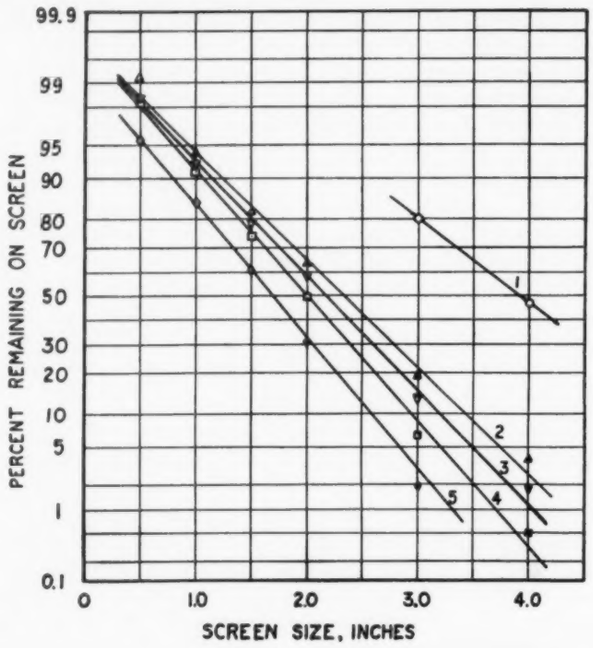

Figure 2 — Same data as in Figure 1 plotted on probability paper.

	Mean size, inches	Spread inch
Curve 1	3.91	0.74
2	2.31	.58
3	2.15	.57
4	1.99	.49
5	1.68	.47

Some, but not all, of these coals were carbonized at both 1650 F and 1830 F (900 C and 1000 C). Their results may not be representative of commercial practice because, for example, the final coke temperature is practically uniform throughout the retort in these tests while in commercial practice it is not; because the coal charge is more nearly uniform in size consist and density than it is in commercial ovens; because of the differences in retort shape and material, etc. In spite of these differences, the tests indicate that changes in coke quality are associated with changes in the proximate analysis of the coal, which are probably qualitatively the same as would be found in commercial equipment under similarly controlled conditions. It must be recognized that it cannot be said that the changes in proximate analysis are the direct causes of the changes in coke quality, but only that, generally, changes in the one occurred in proportion to changes in the other, in the data analyzed. Since the size of the coal and its charge density were held nearly constant throughout the Bureau's tests, the effects of these variables cannot be estimated.

The mean size, M, of the Bureau of Mines cokes can be calculated from the proximate analysis with a probable error of 0.2 in., for the cokes prepared at 1650 F which ranged in mean size from 2.45 to 4.50 in.; and also for those prepared at 1830 F, which ranged from 2.00 to 3.40 in. Variations in the fixed carbon content of the coal on the dry, ash-free basis have an insignificant effect at both temperatures. At 1650 F the effects of ash and moisture contents are about the same; a 1 per cent increase of either increases the mean size about 0.1 in. At 1830 F the effect of ash is more than twice as great as that of moisture, an increase of 1 per cent in ash leading to 0.13 in. increase in mean size.

The spread, R, of the size distribution can also be related to the proximate analysis with similar results. At 1650 F the probable error of the calculated value is 0.05 in. in a range of 0.60 to 1.08 in.; at 1830 F the probable error is 0.06 in. in a range of 0.46 to 1.00 in. As in the case of mean size, the dry, ash-free fixed carbon has an insignificant effect on the spreads of cokes prepared at either 1650 F or 1830 F. Likewise, at 1650 F the effects of ash and moisture content are approximately equal, an increase of 1 per cent in either leading to an increase of 0.02 in. in R; at 1830 F the effect of ash is nearly four times that of moisture, an increase of 1 per cent in ash leading to 0.04 in. increase in R.

The Bureau's data permit an estimate of the effect of final coke temperature on the size and size distribution of the coke. The mean size, M, decreases 0.5 in., and the spread decreases 0.1 in. for a 100 F increase in final coking temperature. Thus, it can be seen that it would take about 5 per cent change in the sum of ash and moisture contents to be equivalent to a change of 100 F in coke temperature.

Data on the reproducibility of size analyses are scanty, but an estimate of the probable error of repeated size determinations indicates that approximately half the errors of the calculated mean size and spread are due to the lack of precision of the screen test itself. Hence. it appears that it would take a change in the sum of ash and moisture contents of 2 per cent to produce significantly different values of the size indices; in other words, coals differing by not more than this 2 per cent in proximate analysis might not appear to differ in size. Experience suggests, however, that differences in coal analysis much smaller than this may produce significant differences in blast furnace operation. Thus, the conclusion is suggested that the standard method of screen analysis may be too crude a criterion of coke quality to be of value in the choice of blast furnace coke; the proximate analysis of the coal and the coke temperature are more significant guides.

SIZE STABILITY

In spite of the extended discussion above, the blast furnace operator is not really interested in the size of coke on the wharf, except insofar as it may determine the size of coke delivered to the furnace and passing through it to the tuyeres. As can be seen from Figure 2, the coke undergoes material degradation in its passage from the coke oven to the blast furnace; M, the mean size, decreases from 3.91 to 1.68 in., while R falls from 0.74 to 0.47 in. in this case because of the breakage suffered by the coke in its successive falls from belt to belt and from belt to bunker. Therefore, some measure of size stability is as important as the original screen

analysis in determining the suitability of coke for bedding in the blast furnace.

Recognition of this fact has led to the use, and abuse, of many tests for the assessment of size stability which are held to determine, to a large extent, the so-called "fuel value" of blast furnace coke. The most generally used are the shatter and the tumbler tests, which have been standardized by the American Society for Testing Materials, but which are also used in various modified forms. One modification of the tumbler test, the Sheffield Drum Abrasion Test,[5] is of interest in that it has been reported to secure a measure of the true abradability of coke by rotating a nearly full drum. In any tumbler test in which the coke is lifted and dropped the results are determined not only by abradability but also by resistance to shatter. Tests designed to measure the hardness of the coke material[6] differ from the above in that the coke is first crushed to particles small enough so that they show no visible evidence of cracks under the microscope and then are subjected to impact crushing. Results obtained in this way are not parallel to those given by other methods of testing, but not enough experience has been gained with these tests to justify an attempt to correlate them with blast furnace practice. In the Wolf pressure abrasion test,[7] on the other hand, a bed of coke is subjected to abrasion while under compression; this test may measure coke properties which are not characterized by any of the other tests described. This may justify its investigation in this country unless better correlation can be achieved between the tests now in use and blast furnace practice.

SHATTER TEST

Results of shatter tests are usually reported in terms of the per cent remaining on a 2 in. or 1½ in. screen, although the A. S. T. M. requires the screen analysis on four screens, ½ to 2 in. As in the case of size analysis, the results are more useful and significant if the data are plotted on probability paper, and the mean size, M_s, and spread, R_s, after shattering, are reported.[8] For instance, there are shown in Figure 3 the shatter test data for cokes made from washed and unwashed coals from the Mary Lee seam. The coke from the unwashed coal has an average size, M_s, of 2.00 in. and a spread, R_s, of 0.55 in., while the values for the coke prepared from the washed coal are 1.62 in. for M_s and 0.32 in. for R_s. It may be noted that the 2 in. shatter index of the "unwashed" coke has a greater average size; yet, owing to the lower R_s value of the washed coke it has 86 per cent between the 1 in. and the 2.5 in. limits, while the unwashed coke has only 63 per cent between those limits.

On the basis of the 2 in. shatter index and of mean size, M_s, the "unwashed" coke would be rated superior to the "washed" coke. It has been pointed out previously, however, that uniform coke size is essential to secure an open, porous stock column in the blast furnace. It is evident, therefore, that the "washed" coke should not be judged on the basis of size alone; its increased uniformity of size, measured directly by the decreased R_s value, is an important justification for undertaking the expense of washing the coal entirely apart from the reduction in ash accomplished.

As in the case of coke size, the size after shatter can be calculated from the proximate analysis and the final coke temperature; and just as in that case, the Bureau of Mines tests are the source of the most extensive comparable data. In this paper only the cokes prepared in the 18 in. retort at 1650 F and 1830 F will be considered. The mean size after shatter, M_s, can be calculated within a probable error of 0.09 in. for cokes

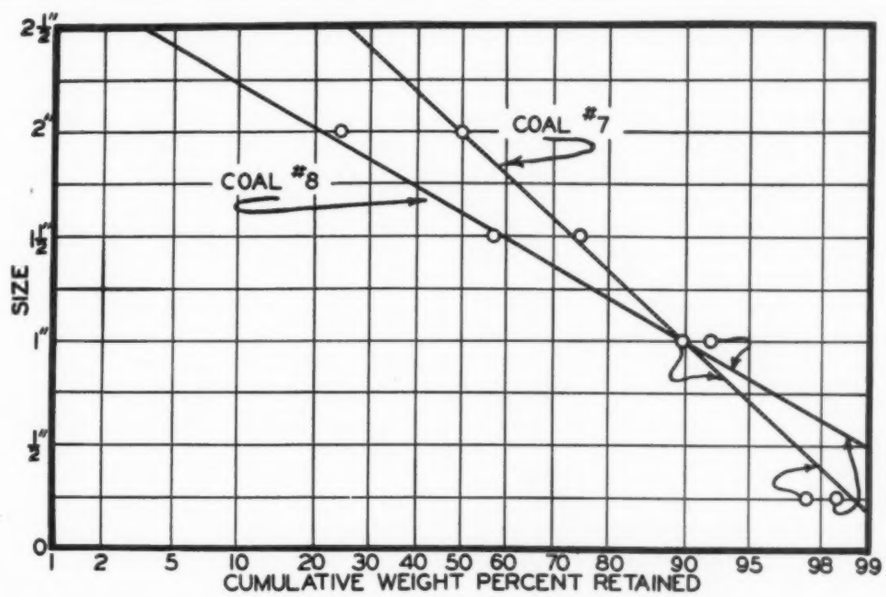

Figure 3 — Plot of shatter test data from cokes made at 1830 F from coals Nos. 7 and 8. Coal No. 7, Mary Lee seam, unwashed, 15.9 per cent ash. Coal No. 8, Mary Lee seam, washed, 8.3 per cent ash.

prepared at 1650 F and of 0.05 in. at 1830 F. The mean sizes range from 1.25 to 2.55 in. at the lower temperature, and from 1.30 to 1.90 in. at the higher one. In this case moisture content of the coal appears not to be a significant factor. The effect of fixed carbon on the dry, ash-free basis is small but appears to be significant, an increase of 1 per cent in its value causing an increase in M_s of 0.021 in. at 1650 F and of 0.012 in. at 1830 F. An increase in ash content of the same amount results in an increase in M_s of 0.034 in. at 1650 F and of 0.018 in. at 1830 F. The spread, R_s, depends only on ash content, an increase of 1 per cent in ash increasing R_s by 0.023 in. at 1650 F, and by 0.017 in. at 1830 F, where the range, at the lower temperature, is from 0.35 to 0.70 in., and, at the higher temperature, from 0.30 to 0.50 in.

Again as in the case of coke size, an estimate of the effect of temperature on size after shatter can be made from the Bureau's data. An increase of 100 F in final coke temperature results in a decrease of mean size after shatter, M_s, of about 0.2 in.; while the same increase in temperature decreases R_s by 0.04 in. A significant effect of this increase in temperature is the decrease in the importance of fixed carbon and ash in determining M_s and R_s as shown in the preceding paragraph. It can be readily seen that the mean size after shatter is much more strongly dependent on the final coke temperature than it is on the analysis of the coal charge. The ash content, on the other hand, is very important in determining uniformity as measured by R_s, since a change of only 2 per cent in ash is equivalent to a 100 F change in coke temperature.

There is some evidence[9] that the results of shatter tests are significantly related to the operation of the blast furnace, but this correlation is, generally, not close. This may be because the characteristic determining blast furnace performance is, not the extent of degradation after applying a given amount of work as in the standard shatter test, but the rate of degradation as the breaking work is increased. A measure of this rate of degradation can be obtained from the results of repeated shatter tests on the same coke sample. The results of such tests on certain blast furnace cokes are shown in Figure 4, in which the mean size after shatter is plotted against the logarithm of the number of 6 ft drops. Except for the points for a single drop, the data fall quite well on straight lines. Perhaps the departures of the points for a single drop occur because the first drop fails to eliminate completely the weaknesses due to the fissuring of the coke. It appears from the figure that coke No. 2 breaks up more easily on repeated dropping than do the others. The magnitude of this difference is measured by the slopes of the lines, coke No. 2 having a slope of 1.30 in. per 10 drops, while the others have slopes of 0.74 and 0.77 in. for coke No. 1 and beehive coke, respectively. Similar results are found when the spread of the size distribution after shatter is plotted instead of mean size; these data are not shown because, for each coke, a linear relation is found between mean size and spread with increasing number of drops. Taking the change in both M_s and R_s into account, it has been estimated that the specific surface of the coke increases in proportion to the amount of work done on it in ft-lb of dropping.

Coke No. 2, which shows a rate of degradation almost twice as great as coke No. 1, has a higher mean size and a greater 2 in. shatter index as delivered at the blast furnace. In spite of the favorable character of these accepted criteria of quality, experience shows coke No. 2 to be less acceptable than the others as blast furnace fuel. The reason is evidently to be found in its high rate of degradation, which may be attributed to its lower temperature of carbonization made necessary at the plant considered by the condition of the coke oven battery. These results suggest that further study and development of the shatter test, especially along the lines of repeated shattering, may lead to a criterion of coke quality which will be more significant for blast furnace operation than is the result of the standard test even when a two number index is used instead of the usual 2 in. or 1½ in. index.

TUMBLER TEST

As used in its various modifications, the tumbler test does not measure any single characteristic of the coke. This is shown by the character of the size distributions found in the product of the tumbler test. The data can be reproduced by two straight lines on probability paper, but the data available are insufficient to determine these distributions uniquely. There is a relatively high correlation between the percentage of the sample retained on the 1 in. or larger screen and the shatter test, which suggests that the degradation to 1 in. is largely the result of shatter. The correlation between the percentage on, or through, the 0.25 in. (or the 0.263 in. screen in the A. S. T. M. standard) and the shatter indices is not high, so this figure may be assumed to measure some other property of the coke, perhaps its resistance to abrasion or attrition.[8] It is possible that a still better measure of this resistance to abrasion would be obtained if a still smaller screen, say ⅛ in., were used as in British practice with this test.[10]

Although the significance of abrasion resistance in blast furnace practice is not known, it is a current impression that a value above a certain minimum is desirable. As in the case of size and shatter, the dependence of the 0.25 in. tumbler test index on the proximate analysis of the coal charge, can be estimated from the Bureau of Mines tests. The index can be calculated within a probable error of 2.0 per cent at 1650 F and of 2.4 per cent at 1830 F, which compares with a probable error of the test itself of 1.2 per cent. The range of values of the index is from 59.0 to 80.1 per cent at 1650 F, and from 62.0 to 82.0 per cent at 1830 F. The moisture content, in itself, has no significant effect on the index. Increase in fixed carbon, on the dry, ash-free basis, increases the index by 0.20 per cent per per cent of fixed carbon at 1650 F, and by 0.24 per cent per per cent fixed carbon at 1830 F. An increase in ash content, however, decreases the index, the effect of ash here being opposite to its effect on the shatter index. An increase of 1 per cent in ash leads to a decrease of 0.80 per cent at 1650 F, and of 0.55 per cent at 1830 F. An increase in coke temperature of 100 F leads to an increase in the 0.25 per cent index in the tumbler test of 1.5 per cent, in agreement with the results of tests on

scratch hardness,[11] but in marked contrast with the effect of temperature on shatter test results.

POROSITY

It has been calculated that a perfect blast furnace would consume approximately 1150 pounds of coke per ton of iron if it operated with an average blast temperature of 1200 F.[12] The most efficient blast furnaces consume about 40 per cent more coke than this, possibly because of the necessity of supplying enough coke to furnish the void volume necessary to carry the burden. If this is the correct explanation of the present coke requirement, the ideal might be met by the use of a coke having an increased porosity. This follows from the hypothesis that more fuel is now provided as coke, in order to meet the void volume required for satisfactory bed structure, than is necessary to meet the heat requirement of the process; supplying sufficient voids to carry the charge could be made compatible with the fuel requirements only by decreasing the apparent density of the coke so that the solid volume occupied produced the required coke rate. Scattered observations of phenomena proceeding from the causes outlined above may be responsible for the general acceptance of porosity as an important criterion of coke quality. In addition, it should be noted that an increase in the porosity of coke produced from a given coal is usually associated with an increase in its resistance to shatter.[13]

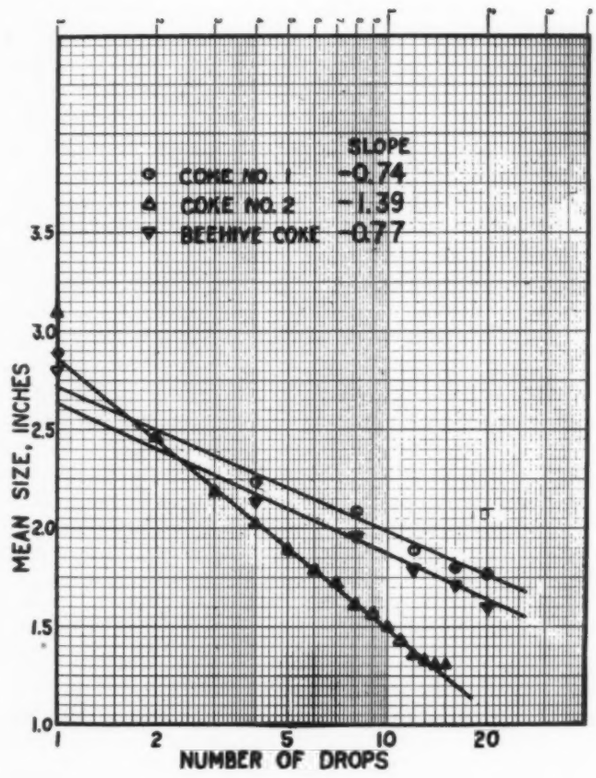

Figure 4 — Dependance of the mean size of cokes after shattering on the logarithm of the number of 6 foot drops.

Porosity, as normally determined, is calculated from the true and the apparent densities. These properties, in turn, are determined by standardized procedures which, however, may not result in measurements closely related to the properties of the material considered as a physical solid. The criticism implied by the last sentence is especially concerned with the true density measurement because the fluids generally used for displacing air in the coke do not completely penetrate its structure. When, however, helium is used as the displacing fluid it has been found[14] that a value of 1.97 for the true density of all high temperature cokes could be assumed with a proable error not exceeding 0.02. The true density of the Bureau of Mines cokes, as normally determined, can, however, be calculated from the coal analysis and carbonizing conditions.[8] Ash, moisture, and fixed carbon of the coal charge and the final coke temperature all affect the calculated true density significantly from the statistical point of view. None of them is important, however, since their effects do not exceed the probable error of the determination over the range that is encountered in practice. The same remarks apply also to apparent density except for the influence of the moisture content of the coal charge. An increase in moisture content of 1 per cent produces a decrease of approximately 0.015 in apparent density at either 1650 F or 1830 F, as compared with a probable error of 0.025.

As would be expected from the above results, the porosities of the cokes were found to depend significantly on the moisture content of the coals charged, but on no other item of the proximate analyses or on the temperature. An increase of 1 per cent in the moisture content increases the porosity 1.1 per cent for the 1650 F coke, and 0.7 per cent for the 1830 F cokes. This may be partly due to the specific effect of moisture on the density of the coal charge, since it is known that the bulk density of a coal charge decreases with increased moisture content to about 10 per cent moisture,[15] and that the porosity of the coke decreases with increased density of the coal charge. Thus, from three charges of Alma coal of 2.1 per cent moisture at bulk densities of 50, 56, and 59 pounds per cubic foot, the Bureau produced 1650 F cokes having porosities of 57.1, 53.4, and 50.5 per cent.

REACTIVITY

Many tests have been proposed to measure the chemical reactivity of cokes although there is no agreement on the significance of the tests and no substantial indication that differences in reactivity have any direct influence on the performance of coke in the blast furnace.[3] The general idea appears to be to measure the specific reaction rate of cokes with oxidizing atmospheres in the expectation of finding a determining criterion for blast furnace use; tests are commonly made with carbon dioxide, steam, air, and even with wet oxidizing agents such as chromic acid in sulphuric or phosphoric acid solutions. It appears that the results

of characterization of a series of cokes by any of these tests are nearly parallel to those given by any other, so that it will be advantageous to use the simplest method available.

One of these simple methods is the Coal Research Laboratory Modified Ignition Point Method[16] by use of which it has been found that the reactivity of coke falls off as its final carbonization temperature increases, and that the reactivity is nearly independent of the properties of the charge as long as attention is confined to high temperature carbonization. This may be the reason for the frequently preference for unreactive coke for blast furnace use; since the value of R_s also falls off as the carbonization temperature increases, decreased reactivity of coke is associated with improved physical uniformity of the charge, and so with improved operating conditions. It is, on the other hand, difficult to explain the preference sometimes stated for highly reactive cokes; the reactivity can have practically no influence on the rate of burning at the tuyeres; its only important effect might be to increase the solution loss from the furnace.[3]

SULPHUR

As already pointed out, the sulphur content of blast furnace coke, which is proportional to the sulphur in the coal from which it is made and is independent of the form in which it exists in the coal, or the final coke temperature,[8] ranges from 0.5 to 1.8 per cent. Satisfactory iron is made commercially from them all. In fact, the sulphur content of the iron made is in the same range as that of pig produced in charcoal furnaces, although the sulphur content of charcoal is only 0.05 per cent. These facts appear to justify a reexamination of the problem of coke sulphur to see if it is, in fact, as serious as it is frequently alleged to be.[17]

It is recognized that anywhere from 66 to 96 per cent (average 92 per cent) of the sulphur entering the blast furnace comes in with the coke, according to published sulphur balances on about 60 furnaces. Anywhere from 67 to 118 per cent (average 85 per cent) of the sulphur entering the furnace leaves in the slag. There is considerable confusion in the fifteen papers published since 1920 on the "desulphurizing power" of blast furnace slag, a portion of which is traceable to the low accuracy of sulphur balances, and a portion to the fact that the mechanism of desulphurization is not yet thoroughly understood. While there is a general impression that slag is saturated with sulphur at about 1.75 — 2.00 per cent, McCaffery and Oesterle[18] have shown that slag minerals, at the average slag temperature in American practice of 2780 F,[19] would contain more than 10 per cent sulphur at saturation. However, this solubility is markedly dependent on temperature so that at 2550 F with certain slag compositions, the limiting solubility might be as low as that usually quoted.

The solubility of sulphur in slag does not, necessarily, yield any information concerning the limiting desulphurizing power of the slag at any temperature, where this is defined as the ratio of the sulphur in the slag to that in the metal after an indefinitely long period of contact between slag and metal; still less does it give information on the rate of approach to this equilibrium condition. While there have been many laboratory studies of the desulphurizing power of blast furnace slag, the conditions evidently differed from those in furnace practice since Sattele[20] found the desulphurizing power of slags from commercial furnaces to be many times that found by Holbrook and Joseph[21] in laboratory studies. At least a portion of the difference is traceable to differences in the time of contact. The importance of the last variable is emphasized by Steudel,[22] who succeeded in reducing slag volume from 1050 pounds to 760 pounds per ton of pig with no increase in iron sulphur, thus materially increasing the desulphurizing power of the slag, by keeping the slag in the furnace longer.

Additional sulphur in the charge generally requires more stone and this increases the slag volume. Hewson[23] in 1920 stated that each pound of ash requires two pounds of stone and each pound of sulphur requires 3.5 pounds of stone. Sweetser[24] stated in 1925 that the addition of one pound of sulphur requires 3.75 pounds of stone. If this is so, an increase of coke sulphur of as much as 1 per cent with a coke rate of 2000 pounds would require only the addition of 75 pounds of stone per ton of pig, or the same amount as is required by about 2 per cent increase in ash. Any addition of stone to a blast furnace charge increases the limeyness of the charge and may bring on hanging and other operating difficulties. These difficulties originate at the bosh or where a sticky slag is first formed. From this point of view, an increase of coke sulphur of 1 per cent is less objectionable than an increase of coke ash of 1 per cent. The acids of the coke ash cannot thin out the slag until the slag passes the tuyeres and picks up the coke ash, but the lime for the sulphur is effective above the tuyeres owing to the desulphurization in the stock column and owing to the fact that the sulphur in the coke is liberated in the gaseous reaction products.

As already pointed out, an increase of sulphur in the coke could also be taken care of by modification of practice as was done by Steudel, by increase in slag temperature, which would, however, result in increased silicon in the iron, or by the use of external desulphurization. The point to be made is that the sulphur problem comes down to an economic one; there is no physical or chemical impossibility in dealing with coke sulphurs much higher than those now considered "good practice;" the only question is whether the increased cost of low sulphur coal can be justified by a balance against the increased costs of operation with higher sulphur coal. The relative values assigned to the reduction of ash and sulphur in coal, however, need reconsideration in the light of the possible changes in practice discussed above.

ASH

The ash in blast furnace coke is determined entirely by the ash in the coal from which it is made, all of the latter remaining in the coke. It acts directly as a diluent of the coke; it requires the addition of two pounds of stone per pound of ash[23] to produce slag of the required quality and thus increases slag volume; the increased slag volume requires additional heat for its melting and results in increased coke requirements, amounting to about 50 pounds per 100 pounds of slag.[22]

In addition to these effects there is an inherent variability in the coke ash, due to that in the coal, which must be taken account of in burdening the furnace. This variability, which increases generally with the amount of ash in the coal,[25] may be the source of fluctuations in iron sulphur content.[26] When the coke ash is close to its average value, performance may be expected to be normal and sufficient lime is present in the burden to slag the ash and to take care of the sulphur as well; when it reaches high points in its fluctuations, the stone normally supplied may be insufficient completely to slag the ash, much less eliminate sulphur from the iron, while when it reaches low points, the furnace may appear to run cold, producing low silicon iron and a viscous slag. Frequently, the main credit, assignable to the washing of coal for blast furnace coke, should be that due to the improved uniformity of the washery product rather than those to the reduction in level of ash and sulphur.

Considering only the effects of ash discussed in the preceding paragraph, it is evident that a calculation of the value of a reduction of ash content by 1 per cent is extremely difficult. When, in addition, the effects on the physical properties are considered, the difficulties are multiplied. It has been shown that an increase in ash not only increases the mean size of coke but also increases its spread in size, the first of which may be beneficial, but the second of which is, almost certainly, not; it has a similar effect on the size after shattering; it decreases the resistance to abrasion in the tumbler test, and it tends to increase the true density of the coke.

From this it may appear that reduction of coke ash to the limit would be an unalloyed advantage. This is not, in fact, the case; a certain minimum slag volume is required for adequate purification of the iron in the blast furnace, and coke ash is probably the least expensive source of a portion of this slag. Thus, it appears that there may be an optimum ash content for minimum cost of operation of any particular blast furnace plant; it is unfortunate that sufficient information is not available to permit the determination of this "best" condition.

MOISTURE AND DRY, ASH-FREE FIXED CARBON

The effects of coal moisture on coke oven practice will not be discussed at this time. The analysis of data in the preceding paragraphs has shown, however, that moisture does directly affect certain physical properties of coke. It tends to increase both mean size and spread; it has only a slight effect on the mean size after shatter and no apparent influence on other results of the shatter and tumbler tests; but its effect is controlling on the apparent density and porosity of the coke. This result appears to justify partly the claim sometimes made that moist coal charges produce better blast furnace coke than do dry ones.

The dry, ash-free fixed carbon of the coal affects the strength criteria perceptibly, an increase in this quantity leading to increased mean size after shatter and an improved quarter inch index in the tumbler test. This may justify the statement that the strength of the coke depends primarily on the rank of the coal, the higher the rank of the coal the stronger the coke, other things being equal. The analysis also indicates that, in blends, the effects of the constituents are additive; thus, the strength of coke can be improved by the addition of low volatile coal.

FINAL COKE TEMPERATURE

In the present discussion properties of the coke have been related to the final coke temperature, which is not simply related to the flue temperature, usually quoted in discussions of coke, but depends on the latter, on the coking time, and on the oven width and charge characteristics. Where direct measurements of the final coke temperature are not available, it may be closely estimated from the hydrogen content of the coke, determined by ultimate analysis.[8] The non-uniform temperature distribution in commercial ovens may mask many of the relations determined from the Bureau of Mines data.

Increase in the final coke temperature decreases the mean size of the coke and also its spread in size, both as pushed from the oven and after the shatter test. While the decrease in size may appear to be undesirable, the improvement in size uniformity is more than enough to compensate for it within the range covered by the data analyzed. Increased coke temperature also results in increased resistance to abrasion as judged by the quarter inch tumbler index. Porosity and sulphur content of high temperature coke are independent of the coke temperature, while the reactivity decreases with increasing temperature.

It has been pointed out that coke quality is commonly considered to determine the efficiency and economy of blast furnace operations. Little or no agreement is found on what determines coke quality. An examination of various tests that are supposed to measure properties of coke has been presented, both as tests of real properties of the coke and as indicators of quality in performance. As a result of this examination, it has been concluded that those properties which determine the contribution of the coke to the structure of the blast furnace stock column should be subjected to control to secure more uniform operation.

The usual procedures of testing coke do not provide adequate control of these structural properties, including size, size stability, and porosity. In the evaluation of coke, the importance of reactivity and of sulphur content has probably been over-emphasized; but the former, at least, is controlled by the same factors as control the structural properties. For a given oven charge, the most important variable is the final coke temperature. Control of the oven charge depends not only on the controlled chemical analysis of the coal, but also on uniform physical structure, which requires control of size, size distribution, and mixing of the coal as well as controlled uniform moisture content, bulk density, and avoidance of segregation.

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DISCUSSION

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C. C. Russell: There is probably no producer of blast-furnace coke, especially the by-product coke plants, that do not have some facilities for making tests of the physical properties of coke produced. Many blast-furnace plants also are equipped for coke testing, particularly where the furnace is supplied with purchased coke. The data from the tests of coke, when compared with blast-furnace operating data, are the source of the information as to what values of the coke properties give the best furnace performance. It may not be unfair to say that more time is given to study of the effect of observed changes in coke properties on furnace operation than is given to consideration of what factors are significant in causing the observed changes. It is not unusual that test data are accepted on their face value and the values are usually taken as absolute.

Dr. Lowry and Mr. Mayers have strongly inferred if not actually stated, that the degree of reproducibility of coke tests is low; that the screen test of coke, for example, is too crude to yield data of satisfactory precision. There is no question that this criticism is well justified if one will reflect for a moment on the methods of sampling in use, the condition of testing equipment, the location of sampling and testing rooms, and even the type personnel employed for sampling and making the tests.

It is probable that the largest source of error in testing coke for physical properties is the sampling procedure used. Sampling practice is often in error due to the taking of inadequate amounts of coke to represent the production; to the short period over which samples are obtained to represent the day's production; and to the improper locations from which samples are removed from the main stream of coke. The A. S. T. M. specifies that 500 lb of run-of-oven coke shall be the minimum weight of sample for sieve analysis of coke and for coke that is one inch and larger in size and free from breeze, 200 lb samples are specified. It may also be interesting to note the final section of the specification for sieve analysis: "In view of the difficulty of obtaining representative samples of coke with regard to size of pieces, even when 500 lb samples are used for sieve analysis, it is desirable to take several samples for sieve tests and average the figures for the several samples." The question may now be raised as to how many blast-furnace coke producers comply with the A. S. T. M. specifications in their daily testing of coke. It is very likely that the combination of errors involved in the sampling and testing of blast-furnace coke may produce deviations from true values that are larger than the actual day to day variation in coke properties. Someone has said that sampling is so important that only highly trained technical men should be employed for the purpose and that untrained men could make the routine tests.

The determination of coke size consist by screen test procedure is not a difficult operation but requires careful and standardized manipulation so that breakage of large pieces is not a variable due to differences in handling. Inspection of the size of sieve openings should be made periodically and sieves should be used that are designed to prevent spreading of the wires while the sieve is in use.

The use of probability paper described by Dr. Lowry and Mr. Mayers presents a new and valuable method for study of sieve analysis. The author has used this

method for a short time and recently, while discussing the data with Mr. Mayers, it was pointed out that the three-inch sieve was actually larger than three inches. Subsequent measurement proved this to be true. This conclusion was reached solely from examination of the plots of sieve analyses on the probability paper.

The accuracy of the size of screen openings is often more important than is generally realized. Some years ago, the author was assigned to the investigation of causes of variation in the physical properties of blast-furnace coke. One of the items for study was the cause of the difference in the values of the tumbler test as made by the coke plant compared to those made by the blast-furnace department on the same coke. It was found that the coke plant was using a screen with one-inch openings and the blast furnace was using a screen with 1.05-inch openings. While the actual difference was small, there was a significant difference in the test values that was the source of much controversy and misunderstanding.

Dr. Lowry and Mr. Mayers have presented a noteworthy paper on a most controversial subject. The use of statistical analysis for blast-furnace data is most definitely indicated and progress has been made. True relationships, however, cannot be established by any method of approach unless the data to be studied represent the values of the various items faithfully. It is believed that great improvement can be made in the sampling and testing of blast-furnace coke for physical characteristics, and it is urged that those in charge of coke testing re-examine their methods.

D. P. FINNEY: The method presented in the paper for plotting screen analysis on probability paper in order to clearly define the breadth and distribution of the various sizes of blast furnace coke appears to be a very logical way to account for the great differences in performance between strong and weak furnace coke. Ordinary comparisons of screen or chemical analyses data from blast furnace plants using strong coke which has been crushed and screened to a desired size with data from plants using weak coke, which cannot be sized satisfactorily, usually fail to account for the great differences which are always shown between the two plants when their coke practice (pounds of coke per ton of iron) is compared. A more complete analyses of the same data, as presented in the paper, would probably show a great difference in the value of R (the breadth of the distribution).

With regard to the analyses of the Bureau of Mines carbonization test on 83 coals showing the effect of the coal quality, density of coal charge, coke temperature, ash and moisture content, etc., we feel that the effect of these various factors must be determined in the individual operating plants. It is definitely known that the effect of the ash content of coal upon the physical qualities of the resultant coke depends largely on the particle size of the extraneous materials in the coal which adds to its ash content

We can agree that the physical tests ordinarily conducted at coke plants are of very little value to the blast furnace operator. They are of great value, however, to the coke plant operator in that they do reflect daily variations in furnace coke quality with a fair degree of accuracy.

We cannot agree entirely with the statement that the main credit assignable to the washing of coal for blast furnace coke should be that due to the improved uniformity of the washery product. If this were entirely true, then efficient mixing equipment would serve the main purpose.

We feel that four important benefits are derived from coal washing, namely, improved physical structure of the furnace coke, a substantial reduction in the ash content, an appreciable reduction in the sulphur content, and a more uniform furnace coke in both chemical and physical properties.

E. J. GARDNER: I think this paper has brought out several new points for our further study and consideration. First, we have all probably concentrated more or less on the screen size and on the plus 2 in. tumbler and shatter tests, and it has been very difficult to correlate the variations which we encounter herein with blast furnace operation. After all, blast furnace operators experience variations just the same as do coke plant operators. Perhaps if we were to break down and study each individual coke size as he suggests, we might find some correlation between a particular coke size and blast furnace operation.

Second, I was very much interested in their first set of graphs, showing the breakage of the coke from the time it leaves the oven until it reaches the blast furnaces. I am just wondering how nearly this might represent a typical or average breakage for all coke plant operators, considering the fact that different types of coal are in use, as well as different methods of handling the coke — cars, conveyors, etc.; also, that our present high-speed operation steps up the tempo of the handling of the coke from the coke ovens to the blast furnaces.

G. T. WILLIAMS: It is interesting to note that the things we do in sampling coke and testing coke are subject to investigation and maybe criticism as to the size of our samples and the amount we do. I know that we make a lot of tests on coke and we look at them and we argue about them and we take them over to the blast furnace, but we don't do anything about them. We cannot tie the control of the blast furnace operation to the variation in the coke test.

I have to run a blast furnace and make coke. We test the coke, but we don't do anything about these tests. There are some who say that the barrel test is a measure of the number of corners on the piece of coke that you put in the barrel and that is about all it is. Certainly these things ought to be some measure of what value the coke is to the blast furnace, and maybe we have been wrong a long time in that we do not take a big enough sample, or in that we do not look at the results in the right way.

W. T. BROWN: I think Dr. Lowry and Mr. Mayers have brought out a very good point, that we are not doing enough testing. Perhaps the Coal Research Laboratory could develop some new tests that might be better suited to determination of the quality of blast furnace coke. I think Mr. Russell has brought out a very excellent point on sampling. The sampling of coke is one of the most difficult things we have to do around the coke plant. We have to have a representative sample and I think it should be given more attention.

It was pointed out in this paper, also, that the main

requirement for good blast furnace coke is uniformity — uniformity of size, structure, and so forth. It carries all the way through from the coal mines to the coke ovens, to the blast furnaces. Keep the size, ash and sulphur uniform for good results in the blast furnace.

H. H. LOWRY: Mr. Russell has brought out a point worthy of much emphasis. Correlation of measures of coke quality with blast furnace operation cannot be expected to be close if the sample of coke tested is not representative of the coke used in the furnace.

We agree entirely with Mr. Finney that the effects of coal quality, coke temperature, etc. on coke properties must be determined in the individual operating plants and that the quantitative relations cited in the paper as determined from the Bureau of Mines data may not be expected to apply to particular operations. It is suggested in the paper, furthermore, that the relations given should be generally correct in a qualitative sense only.

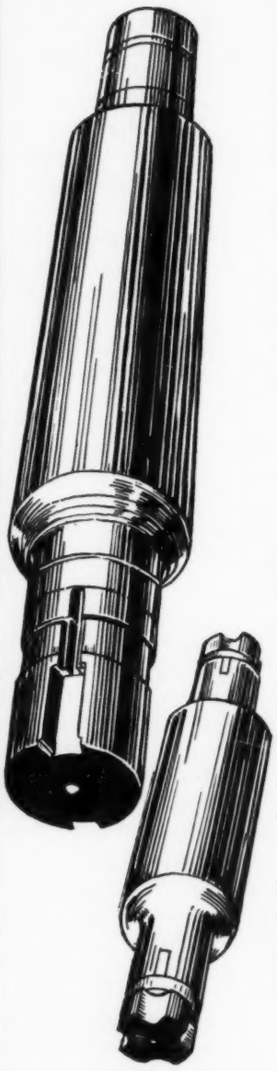
As Mr. Finney also points out, the distribution of ash is known to affect the physical character of the coke, shrinkage cracks originating at small inclusions of slate. It is possible that this effect could be determined quantitatively if, for example, the amount and size distribution of the 1.60 sink in each coal were known. These data are not given in the Bureau of Mines publications, and therefore the analysis of the effect of ash on coke quality was necessarily limited to the amount of ash, which on the average for each per cent increase or decrease produces the changes in coke quality stated in the paper. In other words, lacking data to prove the contrary, the assumption is implicity made that the distribution of ash in the coals tested by the Bureau of Mines is not a variable.

Mr. Finney agrees that one of the benefits derived from coal washing is a more uniform coke in both chemical and physical properties, but states that, if this were the main credit, efficient mixing equipment would produce the same result. It must be recognized that a coal washing plant does produce efficient mixing as well as removes extraneous shale and high ash coal. The removal of these materials unquestionably improves the coke for blast furnace use, though the analysis of the relative importance of the qualities of coke in determining satisfactory blast furnace operation given in the paper leads directly to the conclusion that uniformity is of prime consideration. This conclusion is also supported by the concluding remarks of Mr. Brown.

The graphs showing the breakage of a coke from the time it left the oven until it reached the blast furnace were prepared from a set of data obtained in British practice. It is not known whether these data are representative either of British practice or of American practice. As Mr. Gardner suggests, additional information on this point is needed.

When those in charge of coke testing re-examine their methods, as urged by Mr. Russell, and secure the improvement possible both in the sampling and testing of coke, the results of the tests should be of great value in control both of coke oven practice and blast furnace performance. With significant tests, the situation described by Mr. Williams should no longer be possible and it should be no longer a matter of doubt whether or not the coke is at fault when a blast furnace departs from its normal satisfactory performance.

NATIONAL ROLLS



The Base of Munitions Production

IF rolling mills stopped turning, planes, tanks and ships would stop on the assembly lines and America would be at the mercy of her enemies.

So steel production must INCREASE.

NATIONAL ROLLS are doing their share to ensure a continuance of the present rapid pace.

Carefully planned and compounded from the outset for the work they are intended to do, then cast at the right heat, and finally finished to precision on lathe and grinder, they are well prepared to do their share in defeating our enemies.

THE NATIONAL ROLL & FOUNDRY CO.
Rolls & Rolling Mill Equipment
AVONMORE, PA.

INDUSTRIAL EXECUTIVES!

THE SCRAP FROM YOUR PLANTS IS NEEDED AT ONCE TO KEEP WAR PRODUCTION MOVING!

YOU know that all our furnaces and mills must be kept working at top speed to win this war. Yet the steel industry, already producing record quantities, cannot attain its full, needed war-time capacity of 90,000,000 tons unless 6,000,000 additional tons of scrap steel is uncovered promptly.

This critical situation can be solved only by the patriotic cooperation of every American manufacturer.

In your plant, lying around in repair shops and storerooms, is the scrap America needs to give our boys the fighting tools they must have to win . . .

Broken castings, pipe, obsolete machinery, abandoned line shafting, pulleys, pumps, old boilers, storage tanks, beams, rails, fencing, track, chains, cable, rusty bolts, nuts, and rivets . . .

Round them up and get them moving to the front!

. . . Like the gas appliance manufacturer who searched his plant and found 90 tons of scrap metals . . . or the paper mill that "mined" 1,800 tons of steel from its plants . . . or the rubber company that asked its foremen to "stop holding things" and collected 1,608 tons of iron and steel from old molds and obsolete machinery in a single week!

What others have done, you can duplicate. Walk through your plant with "Scrap" in your mind—you'll be amazed at the harvest. But get it into the fight, *at once* . . . the war won't wait!

★ ★ ★

HERE'S WHAT TO DO... Appoint one man as Salvage Manager for your organization. Give him authority to *act*—to condemn old equipment, to move material, to collect scrap of all kinds. Have him separate all scrap by type. Then move it promptly through your regular scrap dealers. Don't wait — start rounding up scrap *now* — and keep your scrap moving until the war is won!

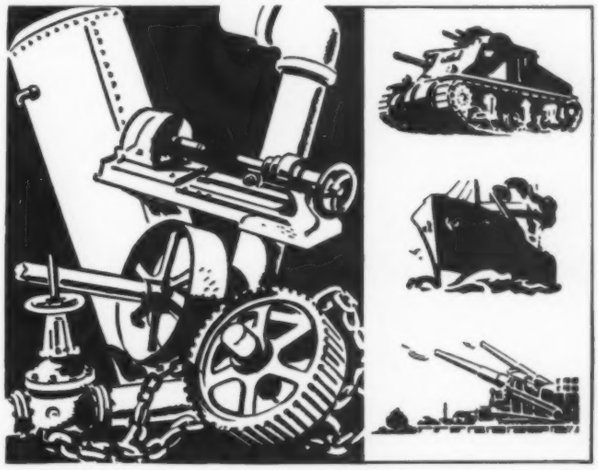
THROW YOUR SCRAP INTO THE FIGHT!

DONALD M. NELSON
says to all industry:

"The shortage of scrap materials for war production is acute. 6,000,000 extra tons of scrap iron and steel alone are needed this year, and vast quantities of rubber, copper, brass, tin, lead and zinc. Without your immediate, active cooperation — whether you have war work or not—we cannot lick this problem. We urge you to organize at once an all-out collection drive in your plants for these materials."

SCRAP NEEDED FOR WAR

SCRAP IRON AND STEEL



50% of every tank, ship, and gun is made of scrap iron and steel!

Other metals—Rubber—Rags—Manila rope—Burlap bags

Thousands of tons of these materials are needed to make bombs, tires for jeeps, surgical supplies for military hospitals, wiping rags for guns, insulation for electric wiring, parachute flares and sandbags.

This message approved by Conservation Division

WAR PRODUCTION BOARD

This advertisement paid for by the American Industries Salvage Committee (representing and with funds provided by groups of leading industrial concerns).

DEVELOPMENTS *in*

Steel Plant Refractories

. . . . improvements in refractories permit the use of higher furnace temperatures, giving increased production rates . . . .

by C. A. BRASHARES

HARBISON-WALKER REFRACTORIES CO.

PITTSBURGH, PENNSYLVANIA

▲ DUE to tremendous demands for steel tonnage at the present time, the improvement of existing types of refractories and the development of new refractories become increasingly important. Because of these demands, however, the availability of commercial furnaces for making service trials of improved or new refractories has become restricted except for those for which there is a good background of related experiences, or for which a very complete and systematic series of indicative laboratory tests is available. It is the purpose of this paper to outline those properties and service results having to do with relatively recently developed refractory products as well as to point out the properties which indicate the utility of a given product for a particular service.

SUPER-DUTY SILICA BRICK

For a number of years, research has continued in the endeavor to find a refractory for open hearth furnace roof construction which would permit the higher furnace operating temperatures necessary for increased rates of production, or for the attainment of certain desired properties in the steel in a shorter period of time. Silica brick have always been the standard material for open-hearth roofs. Consequently, the fact that silica brick of greatly improved properties are now available commercially is a matter of real importance to the furnace operator. Use of the super-duty silica brick requires no change in installation procedure or in operating practice from those now considered consistent with reasonable care.

Since the temperature at which a furnace can be operated is limited by the refractoriness of the roof brick, or the point at which they begin to melt or drip, refractoriness is usually the most important property of these brick. Super-duty silica brick have appreciably higher refractoriness than silica brick of the conventional type and service results to date are very promising.

In laboratory procedure, testing the refractoriness of silica brick offers considerably more difficulty than does testing the refractoriness of fireclay brick or of other brick of the alumina-silica type. Silica brick remain relatively rigid practically up to their melting point, while fireclay brick began to soften at temperatures very considerably below those at which complete melting occurs. It is extremely difficult to measure differences in the refractoriness of high quality silica brick by the Pyrometric Cone Equivalent method — the standard method for alumina-silica refractories. The bending or tipping of silica brick cones at high temperatures is so sluggish that it is difficult for the observer to note differences which may be very significant in actual service. The standard load test however is of real value in determining differences in the refractory qualities of silica brick. For this test the brick are set on end and, with a load of 25 pounds per square inch applied to the other end, are heated according to a definitely controlled

Presented before A. I. S. E. ANNUAL CONVENTION, Pittsburgh, Pa., Sept. 22-24, 1942

heating schedule. In this test, high quality silica brick will withstand a temperature of approximately 3000 F, while recently developed super-duty silica brick withstand a temperature of about 3085 F. The difference is due to the fact that approximately the same amount of liquid or glassy material develops in the conventional type of silica brick at 3000 F as in the super-duty silica brick at 3085 F. In both cases, the liquid phase acts as an internal lubricant, permitting the still solid particles to slide past each other under the action of the load.

Differences in load test results for the conventional silica brick and the super-duty silica brick can be readily explained by a study of the equilibrium diagram CaO-R_2O_3-SiO_2 from which the approximate theoretical liquid percentages indicated in Table I have been calculated.

TABLE I

EQUILIBRIUM MELTING BEHAVIOR

(Based on phase rule diagram: $CaO—R_2O_3—SiO_2$)

Per cent of liquid	Silica brick, conventional type	Silica brick, super-duty
10	1400 C (2550 F)	1670 C (3040 F)
20	1610 C (2930 F)	1690 C (3070 F)
30	1650 C (3000 F)	1695 C (3085 F)
100 (Complete melting)	1700 C (3090 F)	1715 C (3120 F)

While the differences shown in Table I may appear small, they are extremely important from the standpoint of their effect upon the ability of the roof structure to withstand high operating temperatures.

The porosity of the conventional type of silica brick used in open-hearth roofs lies within the range of 22 to 26 per cent. Super-duty silica brick, on an average, have a slightly lower porosity, an advantage with respect to their resistance to penetration by fluxing materials present in the furnace gases. The increase in weight due to lower porosity, however, is not sufficient to cause any complications as to the strength of the supporting steel members of the furnace. For practical purposes, the expansion characteristics of the super-duty silica brick may be considered the same as those of the usual silica brick. Therefore no special precautions need be taken in laying them. While the mechanical strength of super-duty silica brick tends to be slightly less than that of the usual type, they have a good margin of safety for refractory masonry construction and are amply strong for handling and shipping. The resistance of a silica brick to spalling or thermal shock in an open-hearth furnace roof is more or less a secondary consideration. However, it is of interest nevertheless to note that super-duty silica brick are materially more resistant to the effects of rapid changes in temperature both in laboratory tests and in service.

Of the advantages possessed by super-duty silica brick, the most important is their higher refractoriness which permits higher operating temperatures in the open hearth furnace.

Super-duty silica brick have been used in a number of open-hearth furnace roofs, as well as in roofs of other types of furnaces. While the data obtained so far cannot be considered as entirely conclusive, some operators have secured as much as 25 per cent increase in the number of heats. This increased life has come at a time of maximum furnace production and it may be reasone ably assumed that the service conditions have been morsevere than at the time when the roof life for the usual silica brick was recorded.

Figure 1 — Power-pressing refractory brick at high pressure. Air may be evacuated from the clay in the mold during the pressing operation.

SUPER-DUTY FIRECLAY BRICK

Super-duty fireclay brick, developed within relatively recent years, have found increasingly wide application throughout steel plant furnace construction. As compared with high heat duty fireclay brick, they have the advantages of higher refractoriness, materially lower porosity, greater stability of volume and greater strength under load at high temperatures; also greater resistance to the influence of rapid changes in temperature. Because of these properties super-duty fireclay brick are admirably suited for such applications as soaking pit covers which are subjected to temperature fluctuations over a wide range. Marked changes in the properties of refractories have been necessary due to the increasingly severe conditions imposed upon them in soaking pits and similar applications attributable to improved construction which permits greater production. Another wide application of super-duty fireclay brick has been in the various types of heating furnaces in which flame impingement is encountered, localized high temperatures must be withstood or erosion by fuel ash of high alkali content must be resisted. Super-duty fireclay brick have proved economical also in electric steel ladles.

Specially hard burned super-duty fireclay brick or so-called double burned super-duty fireclay brick through their improved physical properties provide still a greater margin of safety in applications in which the conditions are most severe. Although the differences in the properties of the two brick may appear to be very marginal, they are often extremely significant. The

margin of improvement in density for example, a matter of some 2 to 3 per cent, may result in decidedly better performance in applications in which the chemical action of fuel ash or other fluxing agents is encountered. The better load bearing strength of the specially hard burned super-duty fireclay brick may also be an important factor with respect to the life of the refractory construction.

When applying super-duty fireclay brick, it is very important that standard sizes capable of manufacture by the power press method be used to the greatest possible degree. Further reference to this will be made later.

HIGH-ALUMINA BRICK

High-alumina brick are commercially available in the 50, 60, 70, 80, and 90 per cent alumina classes. Some of these, namely, those in the 50, 60, and 70 per cent alumina classes have been used for years to some extent in steel plant furnaces. Brick made from kyanite and sillimanite naturally fall into the high-alumina type of refractories. They have been used in such applications as electric furnace roofs and burner constructions.

Very worthwhile developments have been made in the high-alumina types during recent years. Due to difficulties in connection with imports, further development of brick made from kyanite and sillimanite may be restricted to some extent for the duration of the present emergency.

The refractoriness of high-alumina brick increases approximately in proportion to their alumina content. Brick of the 50, 60, and 70 per cent alumina classes have been manufactured principally from diaspore clays or other aluminous materials. Some difficulties were encountered in the manufacture of brick of the 50 and 60 per cent alumina classes in attaining stability of volume at high temperatures and also resistance to cracking or spalling when subjected to the influence of rapid changes in temperature. By careful studies of correct particle sizing, proper selection of raw materials and the adoption of other improvements in methods of manufacture, brick of both of these classes have been markedly improved with respect to the properties just mentioned. They are superior to super-duty fireclay brick in the high temperature range.

The development of high-alumina brick containing substantial percentages of corundum has been of great importance to the users of refractories. While present limitations in availability of raw materials may also restrict the application of these brick, their outstanding service records in many types of industrial furnaces warrants some brief mention of their properties. One such brick in the 60 per cent alumina class possesses a very desirable combination of properties, namely, exceptionally high strength under load and volume stability at high temperatures, and outstanding resistance to thermal shock. Where these requirements are essential, this brick should be given careful consideration. Furthermore, this brick is extremely resistant to the chemical action of basic fluxes. In many instances in applications involving both high temperatures and chemical action, for example, in oil-fired furnaces using a very heavy or residual oil as fuel, its superiority to brick of the super-duty fireclay type can be demonstrated.

The marked ability of brick of the class of 60 per cent alumina, which contains substantial percentages of corundum, to withstand heavy loads in the high temperature ranges has led to development of similar refractories containing even higher percentages of alumina. These special high-alumina refractories have for some time been more or less accurately considered as comprising a separate class, and adaptation of these to full commercial constructions has been limited. Brick containing 90 per cent or more alumina and composed chiefly of the crystalline, electrically fused alumina, are now finding ever increasing uses on a commercial scale.

Corundum refractories of the 90 per cent alumina class find application in piers, supporting arches and other constructions where loads must be carried in the high temperature range. As an illustration of the load bearing strength of one brand of 90 per cent alumina brick, it is significant that the brick show no subsidence whatever in the high temperature load test used for super-duty fireclay brick and high-alumina brick. In this test a temperature of 1450 C (2642 F) is maintained for 1½ hours and the brick are subjected to an axial

Figure 2 — Left — Arch constructed with large shapes having curved surfaces. These shapes are not adapted to manufacture on a power press. Center — Same arch constructed with smaller shapes which can be manufactured on a power press. Right — Same arch constructed with standard power pressed sizes usually carried in stock. These possess to the highest degree the properties most generally required.

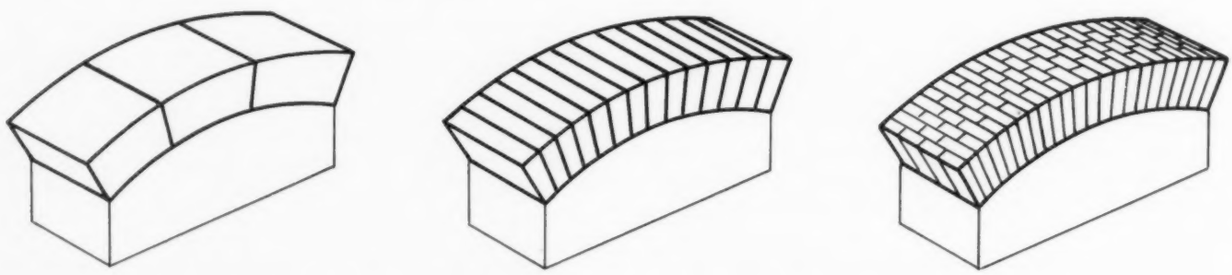


TABLE II

Brand A		Brand B		Brand C	
Furnace pressure, in. of water	Spalling loss, per cent	Furnace pressure, in. of water	Spalling loss, per cent	Furnace pressure, in. of water	Spalling loss, per cent
0.2	1.5	0.15 to 0.5	Uniformly 15.6	0.15	13.2
0.4	7.2			0.35	27.4
0.6	10.8				

load of 25 pounds per square inch. Even at a temperature of 1550 C (2822 F) with the other conditions of the test unchanged, these brick show a subsidence of only approximately 1½ per cent. Very fortunately, these brick have outstanding resistance to thermal shock which becomes evident when they are subjected to the test used for super-duty fireclay brick, wherein a panel of brick is first exposed to a soaking heat of 1650 C (3002 F) and then subjected to a severe spalling treatment. In this test these 90 per cent alumina brick show zero spalling loss.

While the cost of the 90 per cent alumina brick is high in comparison with the costs of the other types of refractories used in the steel industry, the proper application in areas of hardest service, in many instances, will lead to overall economy.

EFFECTS OF FURNACE OPERATION ON REFRACTORY

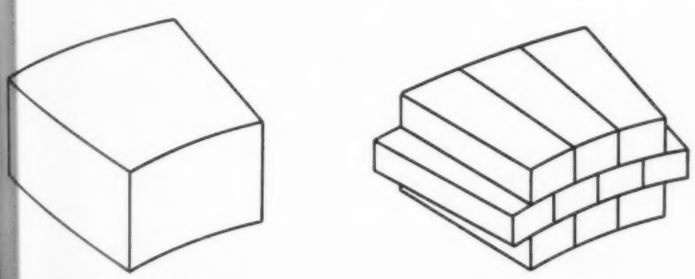
The effects of the many variables in furnace operation upon the life of refractories is well known. For example, the use of heavy residual oils may introduce sufficient amounts of ash of high alkali content to cause severe chemical corrosion as well as mechanical erosion of the brick. In ladles and similar equipment the addition of small amounts of soda ash or other chemicals may lead to considerably reduced life of the refractory linings.

Another variable that may materially influence the life of refractories is gas pressure within the furnace. Studies have been made from time to time of the effect of gas pressure variations, among them some recent work at the National Bureau of Standards reported in Technical News Bulletin of June, 1942. Several brands of fireclay brick were tested for spalling in accordance with the A. S. T. M. test method with the exception that the preheating of the brick at 1600 C was carried out at various furnace gas pressures, namely, 0.15, 0.2, 0.35, 0.4, 0.5 and 0.6 inches of water.

The results of tests for three of the brands tested are given in Table II.

No doubt, practical experience in service and further laboratory tests will add greatly to the information pertaining to the effect of furnace pressure upon the spalling of refractories. With the significant data which has been reported to date, it will be worthwhile to note the possible effects of pressure changes in investigations of the life of refractories in various furnace constructions.

Figure 3 — Left — Large radial brick used for the construction of a circular lining. Right — Standard key brick of smaller volume used with advantage for the same lining. Stresses set up during heating and cooling are more readily relieved.



REFRACTORY DESIGN

Much has been said and written concerning furnace design and construction, but considerably less has appeared concerning the design of refractory shapes. The latter is becoming increasingly important coincident with the advances being made in the manufacture of refractories. When we note that not so very long ago the greater proportion of the refractories used in the steel industry and in other industries as well, were made by the so-called "handmade process" whereas today but a relatively small proportion of the standard sizes are so made, the importance of shape design becomes apparent. It is readily understandable that in the case of handmade refractories, the properties are practically the same for the larger or more intricate shapes as for the smaller more easily made shapes, except when the size or design are such that difficulties attend the proper burning or firing. Today, by far the greater proportion of standard sizes and shapes is made by the machine process, such as the de-aired steam press process or the vacuum power press process. Large or intricate shapes, however, must still be made by hand. For this reason, differences in the properties of standard sizes and difficult shapes of the same material are often very marked, especially with refractories of the super-duty fireclay type.

Very soon after the development of super-duty fireclay brick had reached the commercially successful stage some years ago, they were found to owe their im-

proved properties not only to the high quality of the clays from which they were made, but also very materially to the careful sizing of the clays and the extremely high pressures at which the brick were formed on power presses. See Figure 1. Shapes which were too large or too intricate in design to permit their being formed on the heavy duty presses, were necessarily made by hand. Consequently they did not possess a margin of quality over handmade high heat duty fireclay shapes to even approximately the same degree as was exhibited by power pressed standard sizes over the corresponding power pressed standard sizes of high heat duty fireclay brick. See Figure 2. To overcome this difficulty, a high degree of proficiency in the manufacture of difficult shapes by the air-ram process has been developed. However, to date, this must be looked upon as a compromise at best in securing the desirable properties of super-duty fireclay brick as made by the power press process.

The differences in the properties of brick made by the handmade and the power press processes are not equally pronounced for all the various types of refractories. As has been stated, they are probably most pronounced for refractories of the super-duty fireclay type but the differences exist to a greater or less degree for certain classes of high-alumina refractories and for basic refractories and particularly those which are bonded chemically.

The difference in serviceability of refractories in small units as compared with that of shapes of larger and more intricate design is worthy of careful consideration. A unit approximately equivalent in volume to that of the standard 9-inch straight brick (9 x 4½ x 2½ in. or 9 x 4½ x 3 in.) has decidedly better resistance to the spalling influence of rapid changes in temperature than does a shape of larger size even though both have been made by the same process. Stresses set up during heating and cooling are more readily relieved in small structural units than in large units. See Figure 3.

In the design of any refractory masonry construction, therefore, it is not only desirable from a cost standpoint, but it is good practice from a service standpoint to use to the greatest extent possible, standard sizes in small units capable of being manufactured by machine rather than larger handmade shapes which must be made by hand.

HIGH TEMPERATURE BONDING MORTARS

Of considerable interest is the progress which has been made during recent years in effecting improvement in the bonding properties of high temperature bonding mortars. Their working properties have likewise been greatly improved. This has made it possible to adapt refractories of standard sizes to masonry constructions for which larger or cumbersome special shapes were formerly considered indispensible.

Bonding mortars of many kinds are now available, air-set or heat-set, dry or plastic, among which are mortars having as their base either fire clay, calcined fire clay, diaspore or other aluminous materials, silica, chrome ore, magnesite, forsterite, or carborundum. The wide range of compositions and properties represented makes possible the selection of the bonding mortar individually best suited to meet any particular furnace requirement.

In this discussion, it is not the purpose to comment at length upon furnace design. Obviously this is a matter of great importance not only with respect to furnace production but also with respect to the life of refractory linings upon which uninterrupted high rates of production as well as economy of operation are primarily dependent.

ELECTRIC STEEL FURNACE REFRACTORIES

Inasmuch as the refractory requirements for the electric steel furnace in many instances include rather specialized products, these are being outlined briefly.

The refractories for electric furnace roofs may vary quite widely depending upon the size of the roof and the nature of the operation. Where the roofs are of relatively large diameter, mechanical strength of the refractory at high temperature, is of prime importance. Accordingly, for the larger roofs, silica brick are used most generally. For smaller roofs, advantage may be taken of the somewhat higher refractoriness offered by the super-duty fireclay brick and brick of the high-alumina classes. While the fusion point of silica brick for electric furnace roofs may also depend to a very large extent upon their high strength at high temperatures, even though the brick become impregnated to an appreciable extent by the basic oxides present in the dusts of the furnace gases. Silica brick have the ability to retain to a high degree strength at high temperatures even though high percentages of lime and iron oxides may be present in the brick pores or in the slight spaces between the brick units. Fireclay brick have much less resistance to such destructive influences. The resistance of brick of the alumina-silica series to the effects of basic oxides increases with the alumina content. Accordingly, high-alumina brick of the 60 per cent alumina class have been adapted to roof constructions where conditions of design and service permit. Super-duty silica brick, to which reference was previously made, have also given considerable promise for electric furnace roof construction, since their high refractoriness and particularly their higher resistance to thermal spalling are properties which fit them splendidly for the service.

Basic brick have been used in an experimental way for electric furnace roofs and with continued development of certain types of basic brick and also possibly some changes in roof design, this type of refractory should offer considerable promise.

With increasing severity of operations, the use of hard burned magnesite and metal encased magnesite brick for side walls will undoubtedly increase.

The bottoms of both basic and acid furnaces do not present difficult problems providing that the best available materials are utilized and the bottoms properly installed. Obviously the proper maintenance of a bottom is extremely important.

DISCUSSION

PRESENTED BY

E. E. CALLINAN, Combustion and Refractory Engineer, Timken Roller Bearing Company, Canton, Ohio

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C. A. BRASHARES, Technical Department, Harbison-Walker Refractories Company, Pittsburgh, Pennsylvania

L. A. SMITH: I think Mr. Brashares is to be congratulated on the type of paper he has presented. We as users can't pick up this information as readily as we ought to have it, and here is quite a lot of it.

We have been brought up to date on silica brick and super-duty fireclay brick; we have been told about the most recent developments in the high-alumina brick, and to my mind, the most important thing in the whole paper is the way the author tells us what it means to get shapes down to small sized units, near some standard dimensions. That point is most important with super-duty brick. Those brick came along and did us a pretty good job in 9 in. sizes, then somebody wanted to use them in the nose of an arch and being anxious not to lose a customer, the manufacturer sent shapes with the same names on them but later referred to as super-duty type, and they all went to the devil. Such jobs often failed faster than with cheaper, ordinary brick. I don't hold that seriously against the brickmaker, but it did bring out the point that much of the superior quality depends on high forming pressure. The design of the brick tells you whether you can have these qualities or whether you are just throwing your money away. Mr. Brashares brought that out, and I particularly ask the furnace builders, those fellows we go out and hire to come in and give us the best, to take that lesson home with them. We still get burner openings with great big hunks of brick in them that cost three or four times as much as if they were built out of small units, and we have to like it. The engineering department says, "The contract is written and we won't change a line because so and so won't be responsible for guaranteed performance." Then the furnace is run; soon the big burner blocks are replaced by smaller units and we get some place. I would like the furnace builders to get that point.

I have only one more thought and it is a bit personal. I think the word "super" has been overworked. We talk about this super-duty silica brick. I wish the dictionary had some better word than super. "Super" has been abused, if you ask me. It is going to be nice if we can get 25 per cent more heats with these new brick. Some of us have tried them. I don't see anybody beating any paths to any plant where they are getting 25 per cent more heats, and I know everybody in the industry is complaining — well, maybe I don't know everybody, but most of them — that we can't get quite as long runs out of our open hearths now as we did last year. We say we are beating them on the back; sure, — we are doing a lot of things, and if there is a 25 per cent better silica brick or even a 5 per cent better brick, perhaps it should be called super, but I am a little wee bit from Missouri.

E. E. CALLINAN: I think that is probably a natural tendency of the times. Refractories nomenclature has included the terms "intermediate heat duty" and "high heat duty," and now, "super-duty," as new developments in refractories have been made, and perhaps they are running out of terms at the present time. But at least we know what is meant, since, according to the A. S. T. M. classification, each term denotes a refractory having certain specific properties.

Mr. Smith's remarks on the design of shapes has brought out a very good point. Another important feature of any refractories problem, which Mr. Brashares mentioned, is the proper application or installation of the brick. These two factors are just as important as the intrinsic quality of the brick itself, because with bad design or improper application, the very best brick will not give satisfactory service.

The data on the effect of furnace pressure on the spalling of brick is another point of special interest to combustion men.

While Mr. Brashares' data showed one brick which did not show increased spalling as furnace pressure increased, the data on the other bricks did indicate that spalling increased as furnace pressure increased, and this is the trend which usually prevails.

The pressures shown by Mr. Brashares are higher than those ordinarily encountered in normal furnace operations. They were of the order of 0.4 to 0.6 inches of water, whereas we probably are more used to thinking of furnace pressures of 0.05 to, say, 0.1 inches of water. Nevertheless, according to other ceramic investigators who have run similar tests, the spalling tendency continues to decrease down through these lower pressure ranges which we normally find in our furnaces.

This is another illustration of the interrelationship between combustion and refractories. In other words, the operating conditions of the furnace, as well as the design and quality of the brick, affects refractories life.

R. I. GUMAER: There is one question I would like to ask Mr. Brashares about his tests showing the effect of furnace pressures on the spalling of brick. It would seem to me to make a difference whether that brick was totally surrounded by pressure or whether it was installed in a wall with pressure on only one side. I would like to ask him if in that test the pressure was equalized on both sides of that panel, or whether the brick were exposed to a pressure on one side which would cause a flow of furnace gases through the brick wall. Most furnace walls are subjected to that unequal pressure, causing flow through the wall.

C. A. BRASHARES: The test procedure includes merely the building of the panel into the side wall of a furnace, so that the pressure is exerted on only one face or end of the brick. As I recall, the brick are laid so that the 4½ in. furnace wall is backed with 1½ in. of insulation.

Air Circuit Breaker in the STEEL INDUSTRY

. . . . a survey of the development and improvements of air circuit breakers and metal-enclosed switchgear for industry . . . .

by R. G. LOCKETT

I. T. E. CIRCUIT BREAKER COMPANY

PHILADELPHIA, PENNSYLVANIA

Presented before A. I. S. E. ANNUAL CONVENTION, Pittsburgh, Pa., Sept. 22-24, 1942

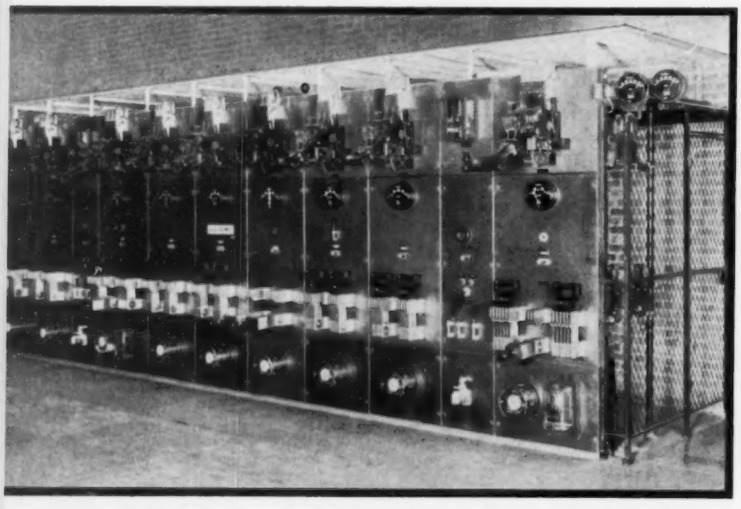
▲ ALL industry uses air circuit breakers, but steel mill engineers are more interested in those used in the steel industry and similar applications.

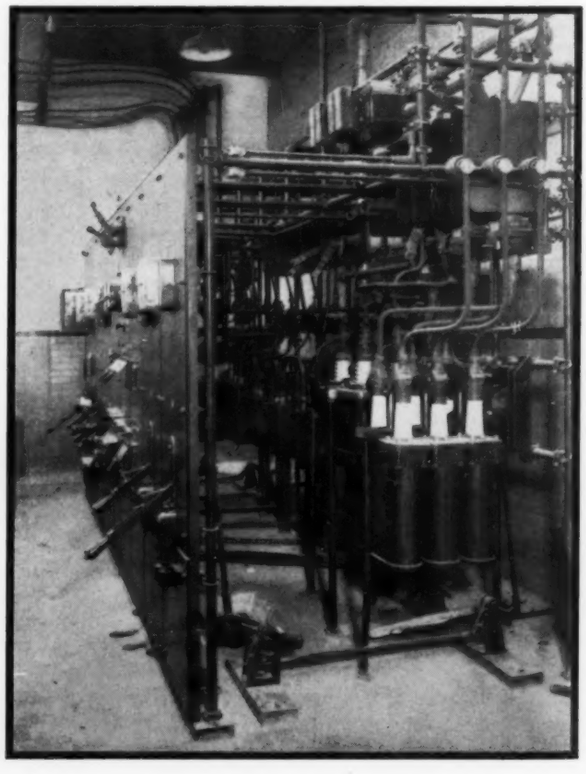
The distribution of power presents about the same problems in all industries. So we find that modern switchgear used for this purpose takes about the same form in steel mills as in other heavy duty applications.

Examining the requirements for distribution of power it is advantageous to scan the development of air circuit breaker switchgear in this field. In a brief discussion such as this, it is probably more useful to discuss circuit breakers from the standpoint of their use, rather than the details of their design.

Figure 1 — Typical example of open switchboard, installed in clean, separate room. (below)

Figure 2 — Open type switchboard built around oil circuit breaker. (right)





Air circuit breakers were first successful in low voltages, where no particular problem exists in extinguishing an arc. The circuits in which they were first used included power units of small size only, so that short circuits of large value were not possible.

Under such conditions, open switchboards developed, built around air circuit breakers plus disconnecting switches. A typical example is shown in Figure 1, an installation in a clean separate room, suitable for the purpose. The advantages of this construction are accessibility and ease of inspection. The disadvantages are lack of isolation of circuits, hazard to personnel and a requirement for a suitable separate room.

This same construction was copied for oil circuit breakers for 440 volts and 550 volts as shown in Figure 2. Many open boards, both air and oil, in low voltages are giving good account of themselves in mills today under the extra demands of war conditions.

But open switchboards and breaker assemblies, by their very openness, invite the entrance of dirt, and unauthorized personnel.

So except for special equipment installed in locked rooms, there is a definite tendency toward metal clad switchgear in standard a-c power distribution schemes. Some sacrifice must be made here, in accessibility at least, as regards inspection in service. This is overbalanced by the gain in isolation furnished by grounded metal walls between circuits and the greater freedom from dirt.

Many steel mill switchgear installations must be made where considerable dirt is encountered normally, and this dirt is often a conductor. Also, small amounts of oil which inevitably cover creepage surfaces wherever oil filled apparatus is used, attract and hold this dirt. Therefore, metal-enclosed gear, designed to exclude most dirt (without dust-tight characteristics however) eliminate service interruption traceable to dust deposits.

In placing circuit breakers in metal enclosures, many service requirements are met, if stationary circuit breakers are mounted in suitable compartments, fitted with hinged doors. Such structures can be made to provide complete isolation of circuits and eliminate all hazards to personnel. But considering mill requirements, two important advantages of the open board have been lost: ease of inspection and a simple, safe disconnect. It is difficult for a mill electrician to give up the simplicity and accessibility of the construction shown in Figure 3 unless the enclosed switchgear offers something better.

This "something better" is drawout construction added to metal enclosure. Such a board is shown in Figure 4 where each individual circuit breaker may be quickly withdrawn for inspection or maintenance. Where required, a spare unit may be just as quickly placed in service. Main circuits are commutated on devices such as shown in Figure 5.

Examination of modern disconnect contacts reveals that much thought has been given to the forces developed during short circuits. These forces are used to increase contact pressure while heavy currents flow. Moving parts or springs are generally mounted on the removable unit, so that they may be readily inspected, when the unit is removed.

Safety regulations in many mills require that any

Figure 3 — The open type switchboard offered simplicity and accessibility.

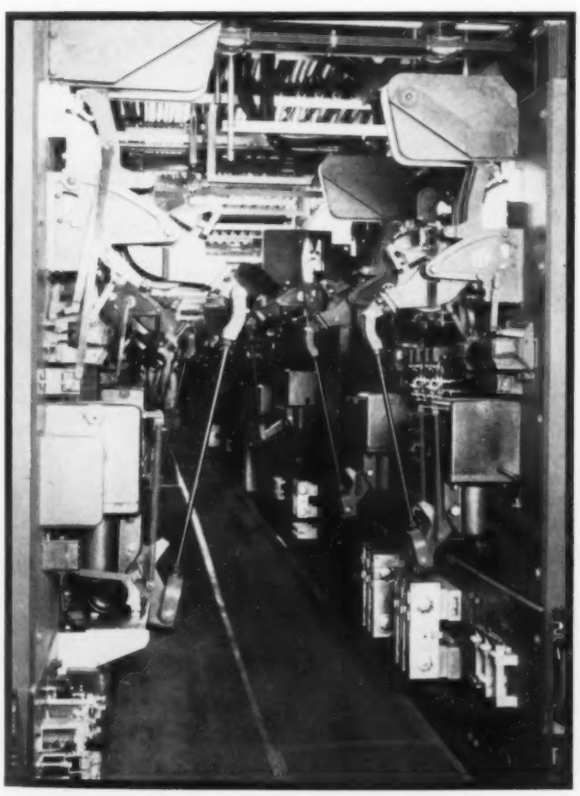


Figure 4 — In the withdrawal type of metal enclosed switchgear, each breaker is easily withdrawn for maintenance.

disconnect device be visible when open, so that a workman may assure himself that all conductors are open before starting maintenance work. To meet this requirement in drawout switchboards the construction may include visibility of disconnects, or an indicator to show position of contacts. Interlocks of positive type, which are always included, may be depended upon to insure circuit opening, on the disconnects, only when the circuit breaker is open.

Thus the isolation of an individual breaker provided by disconnects or bolted links in the older open boards is now provided by disconnect devices, which operate automatically during drawout or replacement. While some operating men in steel mills have felt that these disconnect devices could not possibly be as satisfactory as the older type of disconnect switch or link they are just as positive, and a great deal safer.

Switchgear manufacturers have found that in general, drawout equipment may be built and marketed for very nearly the same prices as stationary enclosed gear, equipped with one disconnect switch per breaker pole. The drawout type offers the advantage of a disconnect on each side of each breaker pole, which provides full instead of partial isolation for inspection and maintenance. Therefore, there is little economic advantage in the stationary enclosed type, considering mill requirements.

Late installations of 440 volt and 550 volt equipment have been almost exclusively of the air breaker type, due to the inherent high rupturing capacity and speed of these breakers and the freedom from oil fires.

Figure 5 — Main separable contacts in engaged position. (top left)

Figure 6 — Withdrawal circuit breaker with handle attached, rated at 1200 amperes. (bottom left)

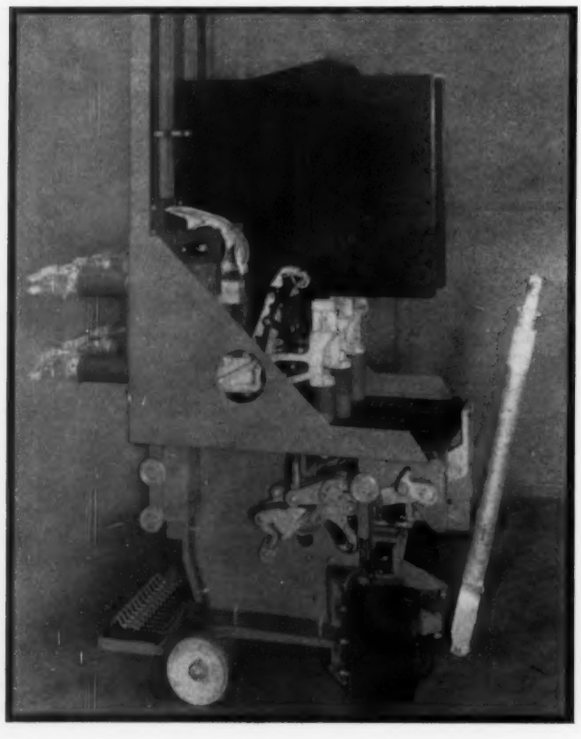
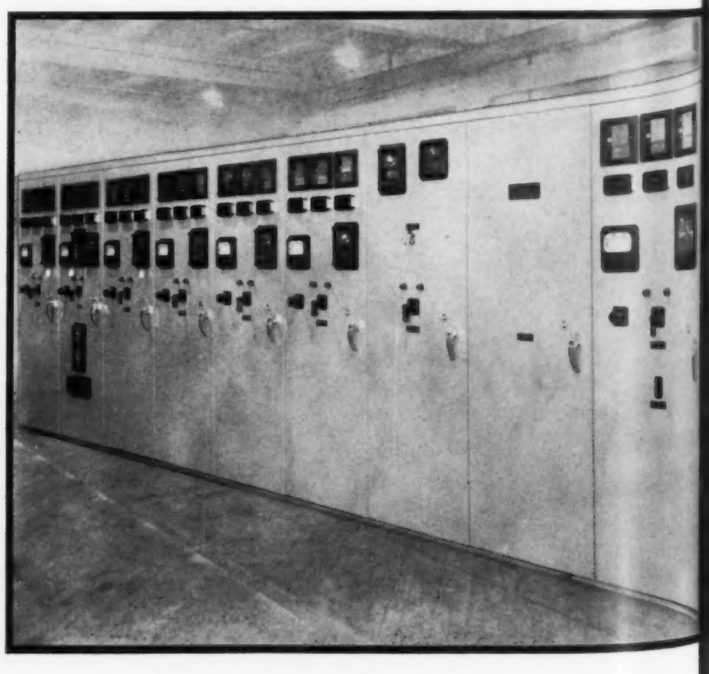


Figure 7 — Withdrawal type switchboard installed in utility plant, using breaker shown in Figure 6. (below)



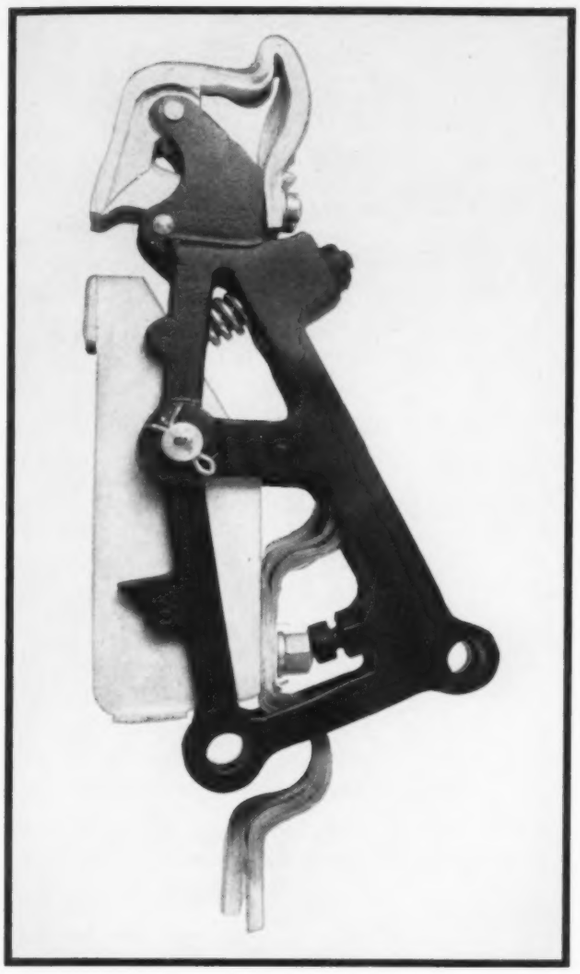
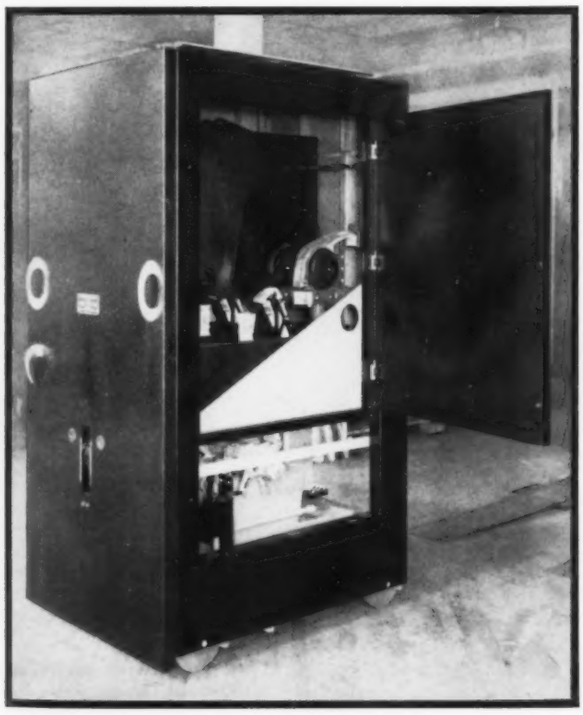


Figure 8 — Bridge and bridge arm assembly forming the contact structure. (left)

Figure 9 — A 7500 volt breaker of drawout type, with arc chute removed showing arc horn and bridge arm. (bottom left)

Figure 10 — This metal-enclosed board was installed in place of the open board shown in Figure 2. (above)



Success of air breakers in voltages below 600 has led to the extension of the air breaker principle to higher voltages at 2300 and 4500 volts in utility power stations and at 6600 volts in steel mills. Steel mills make little use of 2300 and 4500 volt services, preferring 6600 volts, because of greater distribution distances. However the wide use of air circuit breakers for 2300 and 4500 volt auxiliary service by utility engineers is of interest because experience gained at these voltages has helped in development of the 6600 volt device.

A 2300 volt drawout breaker unit of this type is shown in Figure 6, with phase barrier and arc chute removed. The complete switchboard is shown in Figure 7. It can also be built weatherproof for outdoor installation.

The contact structure, which is quite simple, is illustrated in Figure 8. When built for 7500 volt rating in a drawout truck the air breaker is as shown in Figure 9. This particular breaker is used on generator service in a steel mill power plant.

An interesting replacement of open type enclosed switchgear is shown in Figure 10, where a 2300 volt enclosed board occupies the same space originally occupied by open circuit breakers illustrated in Figure 2

Leaving now, the centralized enclosed power distribution system we find air circuit breakers doing many interesting jobs in individual applications.

Air circuit breakers adapt themselves to many special protective schemes such as generator and rectifier protection.

For example, direct current generator breakers, may by the addition of voltage balance relays become automatic devices for measuring voltage or load or degree of short circuit. A typical generator breaker panel of this type is shown in Figure 11. Installed in a steel mill

250 volt d-c substation, this breaker closes automatically on voltage balance, and in combination with an automatic tie breaker, operates automatically in parallel with two similar substations Automatic reclosing on overload or short circuit, is provided. Circuit breakers of similar design as station tie breakers provide automatic reclosing on a load measuring basis.

An interesting development of an air circuit breaker is shown in Figure 12. This device is required to commutate a motor circuit on a d-c steel mill drive in which very high braking currents may be encountered. Under such high current the contacts must not blow open. The circuit loop represented by the breaker studs and contacts would, in a standard device, tend to blow the contacts open. This breaker is built with connections which form a reversed loop so that the mechanical forces tend to press the contacts together during short circuit. Being coil held, without latch, we have here a heavy duty contactor built out of a circuit breaker.

One of the most interesting air circuit breaker developments is in the rectifier field. Increasing adoption of rectifiers instead of motor generators or rotary converters as a source of d-c power, has led to the grouping of large rectifiers on common buses. This introduces protective problems, in case of backfire, due to the large amounts of power involved, and the tremendous rate of rise of the short circuit current on the d-c side.

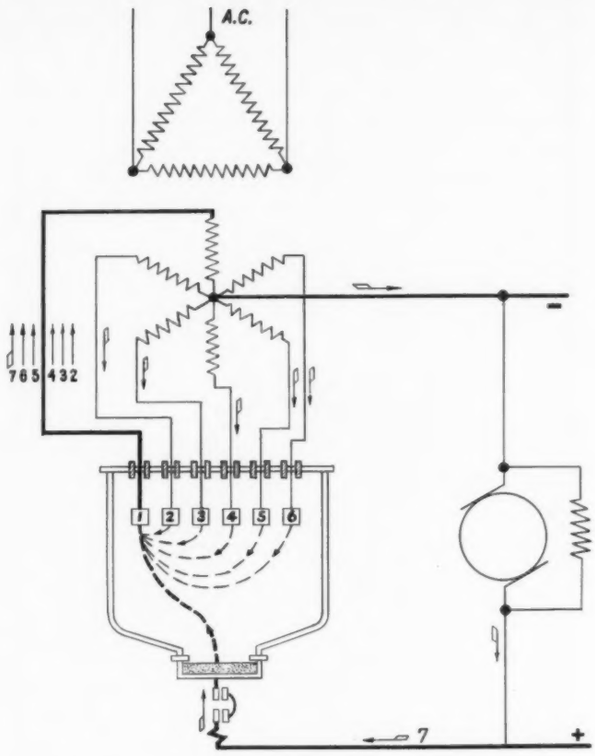
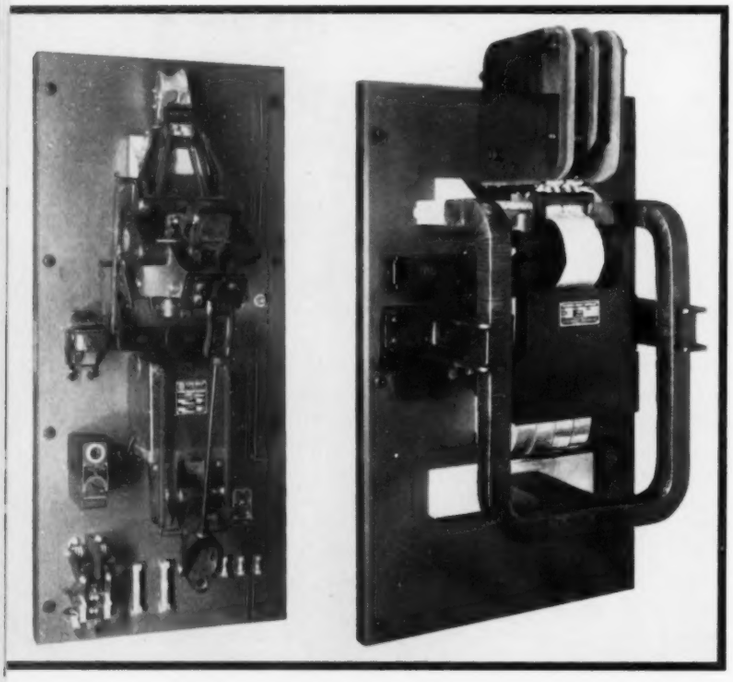


Figure 13 — Diagram showing power flow in six-phase mercury arc rectifier during back-fire.

Figure 11 — Typical generator breaker panel which closes automatically on voltage balance. (left)

Figure 12 — Development of air circuit breaker used to commutate a d-c mill drive motor circuit encountering very high currents. (right)



A backfire is a power arc within the rectifier caused by a failure of the rectification function. They are as yet not entirely predictable but represent no operating problem if interrupted quickly.

A backfire on one rectifier anode represents a short circuit on both the a-c supply, and on the d-c bus, if other rectifiers are operating. Referring to Figure 13, power feeds into the backfire arc from two directions, a-c and d-c. If a-c power is removed from the rectifier, the backfire stops and the d-c short circuit is automatically stopped. Therefore it might be inferred that the thing to do is open the oil circuit breaker feeding power to the transformer. However an oil circuit breaker of the size and rating required for the transformer will be too slow to prevent damage to the rectifier and transformer. So until several years ago it was customary to supplement the oil circuit breaker with a high speed air circuit breaker in the cathode circuit. This cathode breaker in case of an anode backfire, cuts off the d-c power from the anode arc in about a half cycle and leaves only the a-c energy for the oil circuit breaker to handle. This has not been completely satisfactory because, as pointed out, the high tension oil circuit breaker cannot remove power from the backfire arc in time to prevent damage to the rectifier or transformer.

Proceeding on the theory that the right place to open the circuit in case of a backfire is in the anode leads, high speed multipole airbrakers have been developed for that service.

A typical design is shown in Figure 14 which illustrates a six-pole 1600 amp breaker. Each pole can trip separately on backfire in its own anode circuit. Thus part of the problem in obtaining speed is solved by reducing it to terms of a single pole. Part of it is solved by reducing it to terms of low voltage, which requires less contact separation and hence less contact acceleration and travel.

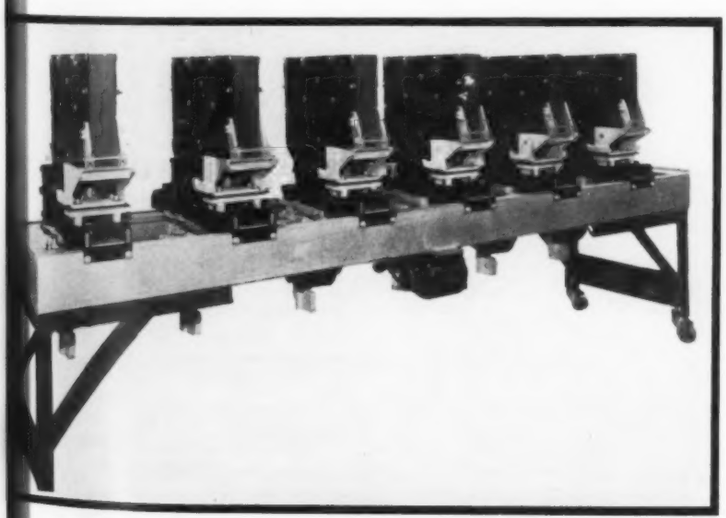
Refinements in arc chute, contact and latch design produced a breaker which could open an anode backfire in one cycle, overall, which means stopping the rise of current in about a half cycle. It was felt that this was about the limit of a good mechanical latch design, and that the opening time was still greater than it should be.

Accordingly a polarized magnet release has been designed, which limits the current rise to a quarter of a cycle and permits overall operation in two-thirds of a cycle. This speed has been satisfactory, because the anode circuit is opened before damage can take place.

The cathode circuit is now equipped with a semi-high speed breaker instead of a high speed breaker. This can be done because the d-c short circuit is now cut off by operation of the ultra high speed anode breaker. The cathode breaker is used for putting the rectifier on load. For energizing the rectifier or taking it off the line the multipole anode breaker is operated with all poles in unison.

Air circuit breakers are not limited necessarily to the lower voltages. In the air blast form they are applied to all higher voltage ratings for which circuit breakers are used.

Figure 14 — High speed multi-pole air breaker developed to open rectifier circuit in anode leads in case of back-fire.



DISCUSSION

PRESENTED BY

M. H. HOBBS, Engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania

F. MOHLER, Engineer, Steel Mill Section, Industrial Department, General Electric Company, Schenectady, New York

T. B. MONTGOMERY, Electrical Department, Switchgear Engineering Section, Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin

M. H. HOBBS: Mr. Lockett's paper is quite interesting in tracing the development of air circuit breakers and metal-enclosed switchgear for industries. It seems to me, however, that it would not be complete without giving credit to the steel industry for its share in the development of this type of equipment. The steel industry was very early and ready in its acceptance of metal-enclosed switchgear, and we have to go back some fifteen to twenty years to find the first steel mill installations of enclosed switchgear of the truck type which was the first type of metal-enclosed gear. In a similar way, field experience in steel mills has clearly advanced the development of air circuit breakers, both for high and low voltage.

There is no question that the design of metal-enclosed equipment has been very much influenced by the requirements of the steel industry, and that the designs are quite largely dictated by these requirements. In fact, I have heard some utility engineers express some regret because this was so. However, I am certain that the designs have not suffered by that, because the steel industry requires the utmost in reliability.

I would say that there is more than simply a tendency toward the use of this type of equipment in steel mills. In fact, there is hardly anything else at the present time. The advantages, in addition to the isolation and the steel enclosure, are the ease of installation and factory assembly and test. Of course, that means that the installation is very simple and very quick to accomplish.

I believe that we will have to take issue with Mr. Lockett's statement that the distribution of power presents similar problems in all industries. Our experience has been that this perhaps is the case for industries other than the steel mills, but that the steel mills have a good many of their own problems which are entirely unique, and which require their own solution.

As far as the air breaker application to steel mills is concerned, it seems to me the greatest contribution has been on the basis of the applications which are tough and couldn't be handled so well by oil circuit breakers. I would like to mention just a few that have had air circuit breakers on them for a number of years, which have been highly satisfactory, and which the oil circuit breakers simply can't handle without excessive maintenance. The modern oil circuit breaker is really a very

high-grade device and very successful. However, there are certain applications where it is not entirely suitable. Three of these "tough" applications are the following. One is on reversing motor duty, which I believe Mr. Lockett touched upon. Another is on high pressure pumps or accumulators for continuous strip mills and other similar mills; and the third is on arc furnaces where we have had breakers for a number of years on both 6600 and 13,200 volt circuits. The highly repetitive operations on all three of these applications are something that only the air breakers have been found suitable for.

In the low voltage field, the most unique application and the one which requires the most ruggedness, is on continuous strip mill duty where we have relatively short connections and high concentration of power, and where the d-c current may run up to 200,000 amperes or more. That takes a real circuit breaker and there isn't anything like it required in the ordinary industry.

I was quite interested in Mr. Lockett's statements in regard to the anode breakers for rectifier service, and he is unquestionably correct about the high speed required to cut off the circuit before the current rises to a very high value. You might be interested in actual figures on this. Our oscillograms have shown that it may run as high as six million to eight million amperes per second current rise, so that it is necessary to get the breaker out in the very minimum of time, if the current is not to build up to a destructive value.

In general, so far as the metal-clad switchgear is concerned, it seems to me the greatest contribution to the steel industry has been to make possible more flexibility in design of the mill, due to the fact that the equipment is safer and can be located where it is in the best position, both from the operation and from length of connection standpoint. There is no question as to the acceptance by the industry, because at the present time practically nothing else is specified, and service experience has been uniformly successful.

F. MOHLER: We have been very active in the development of air circuit breakers, both in the a-c and low voltage field, as well as the a-c high voltage field. A great deal of consideration has been given the application of low voltage breakers in the past few years. For a long time little thought was given to the interrupting ratings, mainly because the concentrations of power were rather limited. However, these concentrations of power have grown by leaps and bounds and the application of proper interrupting ratings has become essential. Rules have been drawn up whereby the proper size of circuit breakers can be selected very quickly, and this has been a great deal of assistance in making the proper application.

Air circuit breakers have been developed for practically all of the ratings both in regard to voltage and interrupting capacity as commonly applied in the steel mills. These breakers are giving an excellent account of themselves and there is a very definite trend toward the use of air circuit breakers for this service.

Although we have developed and applied anode air circuit breakers for use with rectifiers, I would like to bring out one point in connection with this application. Anode circuit breakers have been used by and large in the electro-chemical industry and not in the steel industry because of the large concentrations of power and at higher voltages, that is 600 and up to 700 volts. For such applications they are extremely important and we recommend them highly. The vast majority of applications in the steel industry have been 250 volt rectifiers. So far an arc back on a 250 volt rectifier is practically unknown in the steel industry, and for this reason we do not ordinarily recommend anode circuit breakers for 250 volt rectifiers.

T. B. MONTGOMERY: Mr. Lockett's paper is of some specific interest as it gives virtually in steps the development of one line of air circuit breakers of the magnetic type during the last 12 to 15 years. This was occasioned, as is generally recognized, first by the demands of the unusual concentration of power in the hot strip mill. This reached its peak at nearly 40,000 hp on a single bus.

Later even in cold mills the power outgrew, in some cases, the capacity of conventional contactors magnetically operated. The mechanisms of latched-in air circuit breakers do not permit application to inching and mill setup due to the large number of operations per day with consequent wear and high maintenance.

Figure 12 of the paper shows a 4000 ampere contactor as applied to a three stand tandem mill. Approximately 18,000 hp is connected to this cold mill bus, with total normal rating of some 24,000 amperes. Possible short circuit currents may be expected to exceed 250,000 amperes. This contactor then is designed to blow closed or stay closed on a short circuit. The short is interrupted by a standard air circuit breaker.

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PITTSBURGH, PENNSYLVANIA

▲ WITH the present large productions being rolled by the ferrous and non-ferrous industries being stepped up from day to day, necessitating speeding up of existing mills and cutting of schedules to a minimum number of passes, it seems desirable to again scrutinize the rolling process and attempt to correlate past data and more recent tests so that expected roll neck pressures may be more closely evaluated.

Knowledge of the maximum expected roll neck pressure for a particular mill schedule is of critical importance. When designing new mills, roll size, screwdown design, housing post area, selection of proper capacity bearings and design of a multitude of related mechanical parts are all based on some maximum expected roll neck pressure. The combination of rolling pressure, roll size and reduction in the single pass determine the torque requirements and consequently the motor selection for the new mill. On existing mills which are undertaking drastic changes in rolling schedule, it is necessary to know beforehand just what the proposed schedule change will do to the roll neck pressure so that nothing is mechanically overloaded rather than have continual mechanical failures of bearings, rolls, etc., indicate that excessive rolling pressures were set up due to the schedule change.

Rolling pressure data on existing mills has been obtained for many years by several methods, — direct force measurement, indirect measurement by strain extensometers, and calculation from power tests. Direct force measurement usually involved placing hydraulic high pressure jacks between the screwdown and the bearing chock. This was inconvenient due to constant readjustment of the screws, necessitated by leakage at the jack. Indirect measurements utilizing the strain of the housing posts have been made using carbon telemeters, mechanical dial gauges and various types of electrical extensometers. The most widely adopted of these is the electrical extensometer typified by the pressuremeters,[1] developed to operate remote indicating and recording meters at the operator's desk so that continual observation of the existing roll neck pressure would allow the operator to quickly adjust his mill in case of excessive pressure. Figure 1 shows a typical pressuremeter installation of the flush mounted type. From power tests, it is possible to calculate the rolling pressure approximately by assuming the torque arm to the point of application of the pressure as some portion of the contact chord. This method has several serious drawbacks which will be amplified in the latter portion of this article.

Considerable test data has been reviewed and collected covering actual rolling pressures encountered for various rolling schedules for both hot and cold rolling. As may be expected, most of the available data covers rolling of flat ferrous products, and consequently the following discussion emphasizes the various phenomena which occur in this connection, although the general principles set forth will apply, of course, to the non-ferrous art as well. No attempt will be made to study the pressure phenomena occurring in rolling of various structural and other restrained shapes.

In analyzing the principal factors affecting rolling pressure, primary consideration must be given to the physical properties of the steel being rolled. Chemical

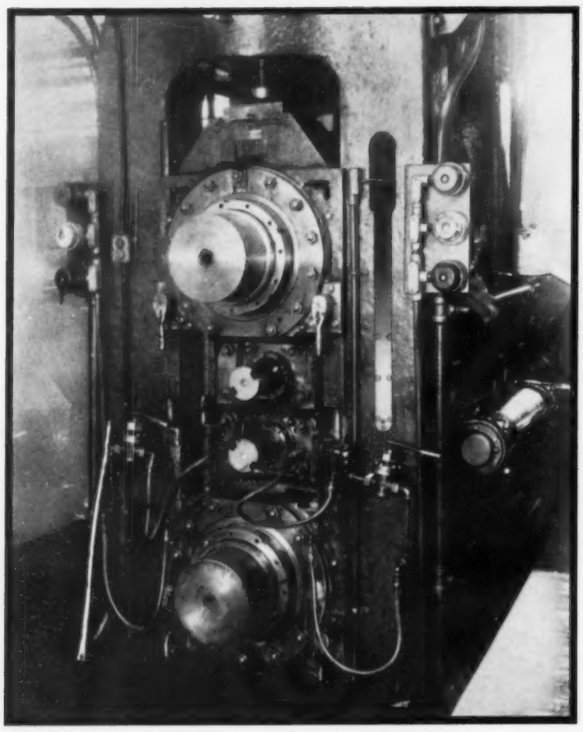


Figure 1 — View of cold mill showing pressuremeter installation of flush mounted type.

analysis and previous treatment of the steel determine just what its physical properties will be at room and at elevated temperatures. In hot rolling, since the steel is being rolled within a temperature range of, say 1950 to 2150 F, at the first scale breaker to, say 1400 to 1600 F, at the end of a finishing train in a hot strip mill, it is important to know the variation in tensile properties as a function of temperature. With hot rolling taking place in general at temperatures above the critical range of the steel, grain refinement and directional banding of segregations and impurities are the only resultant metallurgical changes, and no increase in physical properties due to working are exhibited. Cold rolling, on the other hand, results in a distortion of the existing crystalline structure in the direction of working, causing an increase in tensile and yield strength and a decrease in ductility. The change in tensile properties is directly related to the amount of cold deformation and Figure 2 shows typical test results in the cold working characteristics of a low carbon steel. It is of interest to note that the most pronounced changes of physical properties occurred in the range up to a total elongation of about 1.5 which would correspond to a 33⅓ per cent reduction in the original thickness. Further elongations beyond 1.5 influence the physical properties at a much slower rate.

The next important factor to be considered in its affect on roll neck pressures, is the actual rate of deformation. All metals generally exhibit increasing resistance to deformation with increasing rates of deformation, both in the hot or cold condition, so that correlation between the static or very slow speed tensile properties and the increase due to the high rates of deformation encountered in modern mill practice is necessary. An excellent and thorough series of tests has recently been completed covering the effect of rate of deformation on the tensile properties of pure iron, mild steel, stainless steel, copper and aluminum. [3] In this investigation, reinterpreting for flat rolling, rates of strain are defined as $\frac{T_1-T_2}{T_2 \, x \, t}$, where T_1 is the entering thickness, T_2 is the delivered thickness and t is time in seconds for strip to pass through the contact region between the work rolls. Strain rates from 10^{-5} to 10^{3} elongations per second, which is a range of 100,000,000 to 1, were studied for a wide range of temperatures, and Figure 3 shows the test results as they effect the ultimate strength of mild steel at various temperatures. Ordinary rolling rates vary within the range of from 1 (10^{0}) to 10^{3} for both hot and cold rolling. Note that in the usual hot rolling range above 1400 F there is always an increase in ultimate strength for an increase in rate of deformation even though no attempt is made to remove the additional heat due to more rapid plastic flow. Therefore, greater internal heating because of increased rates of deformation is not necessarily sufficient in itself to cause any reduction in ultimate strength. Under actual rolling conditions, however, the external heat generated due to the friction between the rolls and the material undergoing plastic deformation may be sufficient when added to the internal heat of deformation that an actual reduction in physical properties may occur at the increased rates of deformation. In cold rolling, especially, high localized temperatures undoubtedly exist in the region undergoing plastic deformation and certainly this must affect the resistance to deformation.

Another common way of expressing the affect of speed has been to use the rate of compression defined as $\frac{T_1-T_2}{T_1 \, x \, t}$ with all notations as defined previously. Figure 4 covers some earlier tests[3] showing how the resistance to compression varied at different temperatures with varying rates of compression. The actual test conditions must be carefully reviewed before the test results are applied to some particular mill rolling condition. Observe that the delivered strip thickness varied from 1.18 to 0.2 in.; that the rolling was done at constant speed and that the different rates of compression were obtained by starting with different thicknesses of strip. With modern hot strip mills rolling to finihed gauges of less than .050 in. and since, as will be developed later, the actual strip thickness and reduction in the pass are critically important, care must be taken that this test data which accurately covers a definite range of conditions is not seriously misapplied.

Another phenomenon that we wish to study and emphasize revolves around the effect of friction in the bite of the rolls. Although it is friction that makes rolling possible, it is also this influence that determines the limits of its possibilities. As has been shown by von Karman[4] and further developed by A. Nadai,[5] it can be shown that the condition for equilibrium of the horizontal forces when deforming any small column of

material under compression between two flat compression plates taking into consideration the frictional resistance or a shearing stress τ along the compression plates, is given by:

$$\frac{dp}{dx} = \frac{-2\tau}{T} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1$$

where p = compression pressure, psi.
x = distance from center of pressure region to point under consideration, in.
τ = shearing stress, psi.
T = strip or plate thickness, in.

Now, depending on the assumption of the type of frictional condition existing between the compression plates and the plate undergoing compression, several pressure distribution curves may be obtained. Assuming that $\tau = \mu P$ where μ = coefficient of friction,

$$\frac{dp}{dx} = \frac{-2\mu P}{T} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2$$

Integration of this equation for a very wide strip, of length L gives us,

$$p = s_0 e^{\frac{2\mu}{T}\left(\frac{L}{2} - x\right)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3$$

where it is assumed that at each point x, flow is governed by the condition

$$p + s = s_0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4$$

This latter condition merely states that plastic flow is at constant shear stress $\frac{s_0}{2}$, where s_0 is constrained yield strength, which for flat rolling equals 1.155 times the normal yield strength, p is normal compression to sheet and s is normal tensile stress at x parallel to sheet. For future correlation purposes, we wish to use the average stress which is defined by

$$p_{ave} = \frac{\int_{-\frac{L}{2}}^{+\frac{L}{2}} p\,dx}{L}$$

$$\therefore p_{ave} = s_0 \left(\frac{e^{\frac{\mu L}{T}} - 1}{\frac{\mu L}{T}} \right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5$$

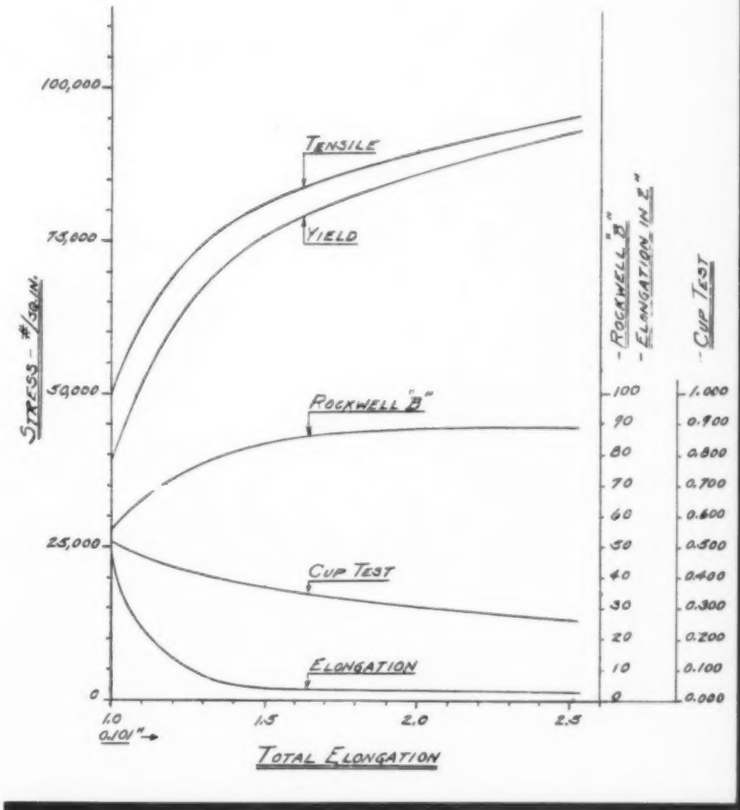
Thus, the average pressure required to cause plastic flow of the material between the flat compression plates is equal to the constrained yield strength s_0 times a numerical factor which is determined by the ratio $\frac{\mu L}{T}$

Thus relationship is interesting in that for a given condition of lubrication or lack of lubrication, the average pressure depends on the ratio of contact length, L, to thickness of material, T, and Figure 5 was prepared to show how rapidly the average pressure increases with increasing ratios of $\frac{\mu L}{T}$. Although a great increase in required pressure $p_{ave.}$ is indicated as $\frac{\mu L}{T}$ increases, there is no indication of itself that $p_{ave.}$ reaches *00* at any given value of $\frac{\mu L}{T}$. Sachs[6] derives an expression

$$p_{max} = \frac{s_0}{1 - \frac{\mu L}{T}}$$ which states that at the value of $\frac{\mu L}{T} = 1$, the required p_{max} stress reaches an *00* value. This difference in results is due to differences in assumptions of type of plastic flow and the expression derived in equation 5, seems to the writers to more properly express true conditions, as well as more accurately predict quantitative results. Although the above derivation rigidly holds for compression between flat plates and for the assumed friction relationship, calculations based on actual roll neck pressure tests indicate that it can be applied with reasonable accuracy to rolling pressure calcuations, where the average thickness of the strip is used for thickness T. Note that the constrained yield strength, s_0, is dependent on the temperature and rate of deformation of the material being rolled and would be obtained from the test data of Nadai and Manjoine or from similar tests.

Let us examine the factors affecting this $\frac{\mu L}{T}$ ratio,

Figure 2 — Typical cold working characteristics for low carbon steel.



of which the first is the coefficient of friction, μ. Unfortunately, there is great discrepancy in the recommended coefficients of friction to be used at various temperatures and for various other rolling conditions. In the past, Tafel and Siebel, Ekelund and Pavloff have reported tests covering coefficients of friction at various temperatures. A comparatively recent series of friction tests were also reported.[7] It was subsequently suggested[6] that for hot rolling, coefficients of friction equal to 80 per cent of Ekelund's values would give most reasonable results and these values will be used throughout the remainder of this article. In general, the coefficient of friction increases with increasing temperature from room temperature up to 1200 or 1300 F, after which it drops steadily with further increase in temperature. In hot rolling, 80 per cent of Ekelund's figures for chilled iron rolls indicate that at 1400 F, the coefficient of friction would be about 0.55 and would decrease to about 0.42 at 2000 F. In cold rolling, Trinks reports values as low as 0.04 for high speed rolling and flood lubrication, 0.15 for artificially roughened rolls and flood lubrication and from 0.09 to 0.11 for smooth, polished and dry rolls.

The next factor in the $\frac{\mu L}{T}$ ratio to be considered is the value of L. As calculated on a rigid roll basis, that is, on the basis that no roll deformation takes place, the contact chord is obtained from the familiar relationship,

$$x = \sqrt{R(T_1 - T_2)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6$$

where, x = rigid contact chord, in.
R = roll radius, in.
T_1 = entering thickness, in.
T_2 = delivered thickness, in.

Roll flattening occurs, however, and the actual contact length L may be calculated from the following expression,[6]

$$L = \sqrt{x^2 + x_0^2} + x_0 = x_2 + x_0$$

and

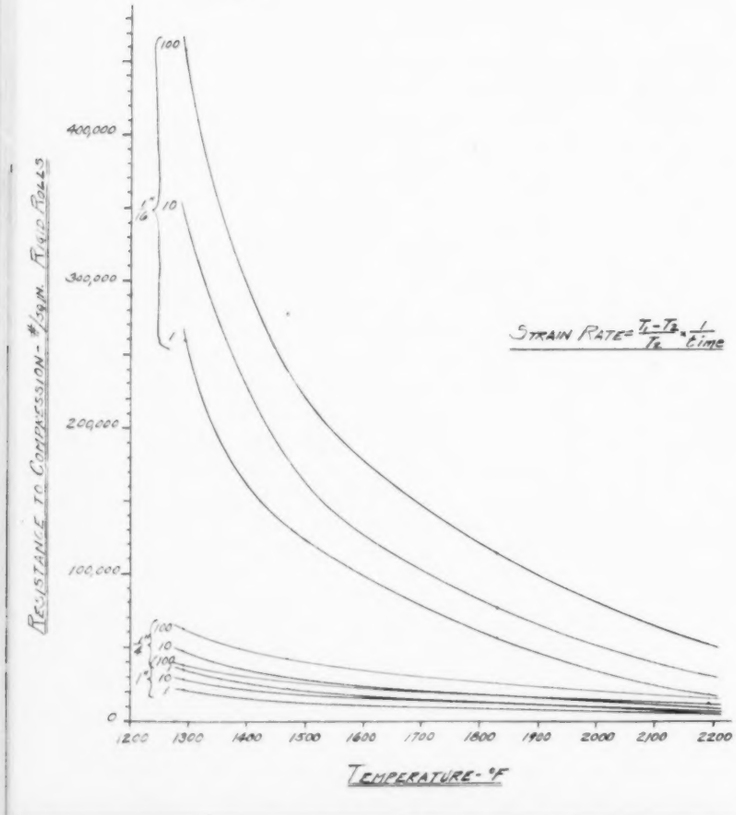
$$L = \sqrt{R(T_1 - T_2) + \left[\frac{8R(1-\sigma^2)p}{\pi E}\right]^2} + \frac{8R(1-\sigma^2)p}{\pi E} \qquad \ldots (7$$

where σ = Poisson's ratio ($=0.3$).
p = specific rolling pressure, psi.
E = modulus of elasticity of roll, psi.

where x_2 represents the flattened contact length on the entering side of the vertical diameter through the work rolls while x_0 represents the flattened contact length on the delivery side of the vertical diameter. Note that for a given value of p, the contact length L decreases with decreasing roll size and percentually decreases faster than the rigid contact chord and therefore, from a theoretical viewpoint, the smaller the roll size the less important the flattening. This is in addition to the fact that the smaller roll has a smaller contact chord and, therefore, requires less total pressure for the same reduction. It is also evident that the roll material itself also affects flattening, for the lower the modulus of elasticity of the roll material the greater the flattened contact length for the same rolling conditions. Roll flattening thus becomes increasingly important as the material being rolled becomes thinner and harder and Figure 6 was prepared based on actual pressure measurements, to illustrate the significance of this flattening. Five passes of a typical reduction schedule on a reversing mill are shown with the actual rigid contact lengths and the flattened contact lengths. A ratio of $\frac{L}{x}$ of 1.09 existed in the first pass with a gradual increase occurring up to a ratio value of 2.48 in the last pass. Two illustrated skin passing conditions show enormous increases in contact length due to roll flattening, with the last illustration showing how an apparent rolling pressure of 806,000 psi based on rigid contact length decreased to only 110,000 psi based on the flattened contact length. The illustrations also show how the increase in contact length due to roll flattening occurs principally on the delivery side of the vertical diameter of the rolls, thus tending to bring the center of the pressure region closer to the vertical diameter of the rolls, which behaviour will be discussed later.

The last factor to be considered in the ratio $\frac{\mu L}{T}$ is average strip thickness T. As T is decreased, for constant values of μ and L, the ratio increases and consequently greater resistances to compression are set up. To illustrate the importance of actual strip thickness, Figure 7 was prepared showing theoretical values of

Figure 3 — Curves showing effect of rate of strain upon ultimate strength of mild steel at various temperatures.



resistance to compression when taking the same .030 in. reduction, using 20 in. diameter work rolls, for three different starting thicknesses: 1.030 in., 0.280 in. and 0.093 in. The basic values of constrained yield strength were taken from the tests of Nadai and Manjoine. Note that at 1300 F, the 0.093 in. strip indicates about 12 times the specific resistance to compression over the 1.030 in. plate, if calculated on the basis of rigid rolls, that is, no roll flattening. If roll flattening is allowed for, the $\frac{\mu L}{T}$ ratio would increase even more rapidly for the thinner plate since higher specific pressures are required, and there would be still greater spread between the pressures required for the 1.030 in. and 0.093 in. plate.

Data from the hot rolling tests of Siebel and Fangmeier and several test points obtained on high speed hot strip mills were prepared and are shown in Figure 8. The tests of Siebel and Fangmeier yield surprisingly close agreement with the expected results based on the use of the multiplication factors determined by the $\frac{\mu L}{T}$ ratio. The other test points emphasize the high resistances to compression that actually exist with typical rolling schedules. Similar test data on cold mills have been checked in an attempt to confirm this effect and based on assumed friction coefficients of 0.05, close agreement has been obtained between the constrained yield strength and the pressure multiplication due to the $\frac{\mu L}{T}$ ratio. Skin passing data, when checked, using a coefficient of friction of 0.10 showed the same reasonably close agreement between the constrained yield strength for the particular rolling conditions and the measured average resistances to compression for the flattened contact condition. Considerable variation of the test figures can be obtained by varying the assumed friction coefficients and it would be too optimistic to expect perfect prediction of the required resistance to compression for a given rolling condition. However, the data that has been examined indicate that the pressure multiplication factor $e^{\frac{\mu T}{L}} - 1$ can be applied to all flat rolling conditions to explain quantitatively and with reasonable accuracy the spread between the constrained yield strength and the exhibited resistance to compression.

The effect of tension on the required rolling pressure has been covered in several excellent papers[6] and will be only briefly noted here. From the established facts covering plastic flow of ductile metals under combined stresses, it is known that if an element of metal is undergoing compressive deformation, the required compressive force can be diminished by application of tensile forces at right angles to the direction of compression because flow takes place when the difference between any two principal stresses becomes equal to twice the shearing strength of the metal. (See equation 4.) Thus, tension, in the strip, applied at right angles to the

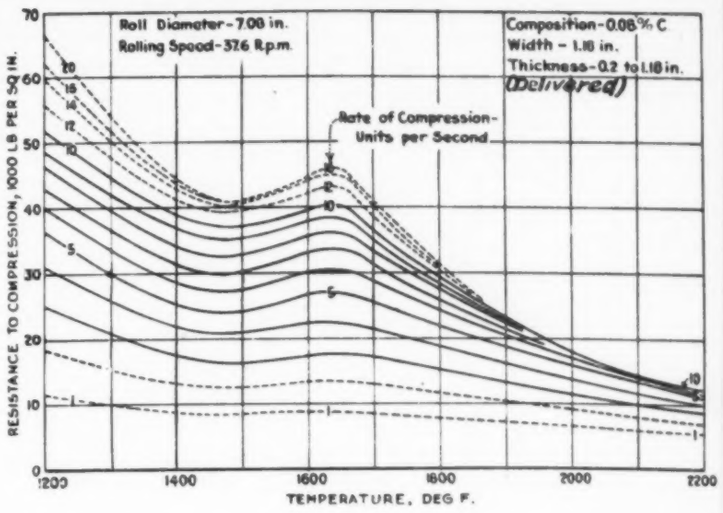
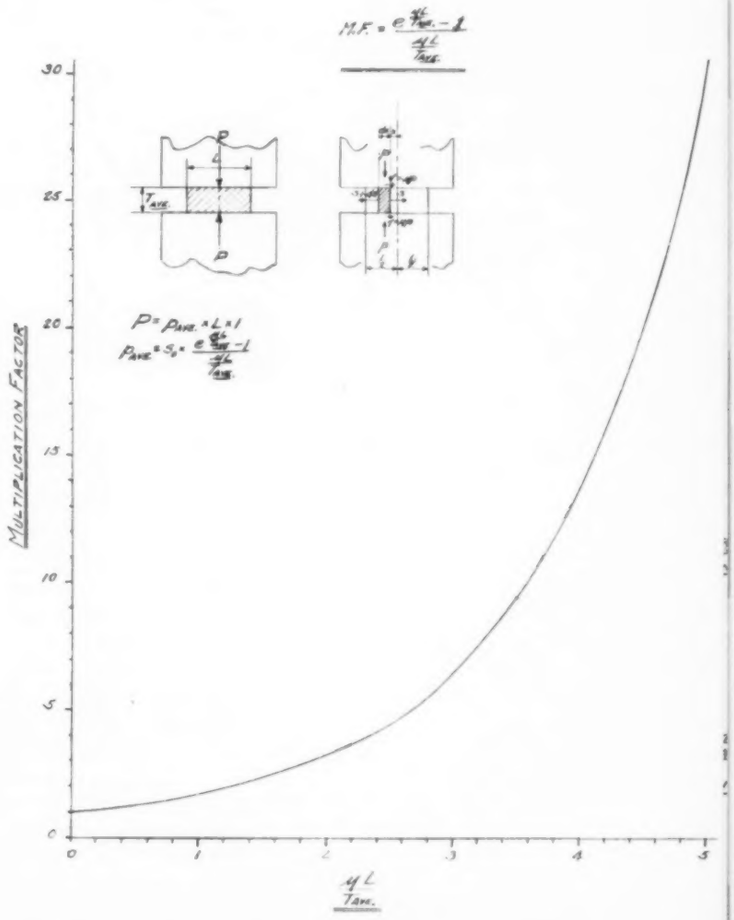


Figure 4 — Curves showing test data on resistance to compression at various temperatures and rates of compression.

Figure 5 — Pressure multiplication factor for various value of $\frac{\mu L}{T_{ave.}}$


M.F. = $e^{\frac{\mu L}{T_{ave.}}} - 1$ / $\frac{\mu L}{T_{ave.}}$
$P = p_{ave.} \times L \times l$
$p_{ave.} = S_y \cdot \frac{e^{\frac{\mu L}{T_{ave.}}} - 1}{\frac{\mu L}{T_{ave.}}}$
MULTIPLICATION FACTOR
$\frac{\mu L}{T_{ave.}}$

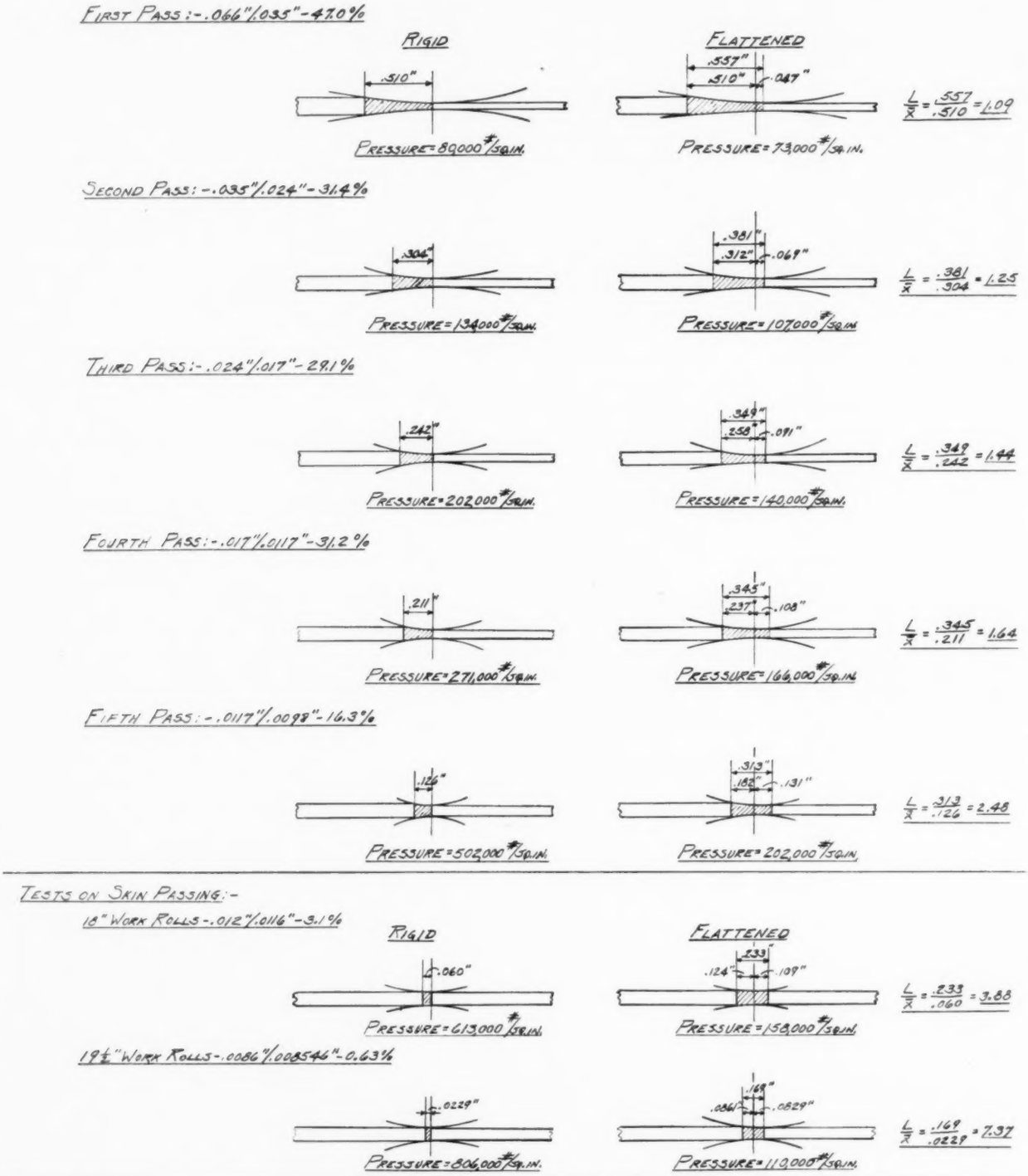


Figure 6 — Sketches illustrating typical roll flattening.

direction of compression of the strip in the bite of the rolls, reduces the required rolling pressure. This decrease in specific roll pressure becomes important from a practical standpoint, for the decreased pressure reduces the flattened length of contact of the roll which decreases the $\frac{\mu L}{T}$ ratio, causing further decrease in pressure and further reduction in the flattened length of contact, and so on until a cumulative balanced condition is reached. Thus, in rolling conditions where roll flattening causes the major portion of the pressure, the cumulative reduction in pressure becomes considerable and may mean the difference between successful and unsuccessful rolling. This is typified by present practice in skin passing of tin plate gauges where practical experience and theory agree that tensions should be used

the torque arm at which the total rolling pressure acts as though concentrated. Referring again to Figure 6 and assuming that there is neither front nor back tension and no roll flattening, the pressure distribution for the rigid roll contact would vary symmetrically from a value corresponding to the constrained yield strength s_0 at each end of the contact region to some peak pressure at very nearly the midpoint of the contact chord. Accordingly, the total rolling pressure can be quite accurately obtained from the relationship,

$$p = \frac{R.\,T.}{2xkx} \qquad \text{.....(8}$$

p = total tolling pressure, lb
$R.\,T.$ = rolling torque, in-lb
k = distance factor
x = rigid contact chord, in.

THEORETICAL

						T_1=1.030" T_2=1.000" T_1-T_2=.030" 20" DIA. ROLLS					T_1=.0280" T_2=0.250" T_1-T_2=.030" 20" DIA. ROLLS					T_1=.093" T_2=.063" $T_1=T_2$=.030" 20" DIA. ROLLS				
TEMP.	RATE OF STRAIN	STRESSES ULTIMATE	YIELD = .6 ULT.	S_0 = 1.155 YIELD	μ	$\bar{x}$	$T_{AVE.}$	$\frac{\mu\bar{x}}{T_{AVE.}}$	$\frac{e^{\frac{\mu\bar{x}}{T_{AVE.}}}-1}{\frac{\mu\bar{x}}{T_{AVE.}}}$	RESISTANCE TO COMPRESSION	$\bar{x}$	$T_{AVE.}$	$\frac{\mu\bar{x}}{T_{AVE.}}$	$\frac{e^{\frac{\mu\bar{x}}{T_{AVE.}}}-1}{\frac{\mu\bar{x}}{T_{AVE.}}}$	RESISTANCE TO COMPRESSION	$\bar{x}$	$T_{AVE.}$	$\frac{\mu\bar{x}}{T_{AVE.}}$	$\frac{e^{\frac{\mu\bar{x}}{T_{AVE.}}}-1}{\frac{\mu\bar{x}}{T_{AVE.}}}$	RESISTANCE TO COMPRESSION
2192°F	1	5600	3360	3580	0.37	0.548"	1.015"	0.199	1.11	4310	0.548"	0.265"	0.765	1.50	5820	0.548"	0.078"	2.60	4.81	18700
	10	9400	5640	6510		"	"	"	"	7740	"	"	"	"	9750					31300
	100	15600	9360	10800		"	"	"	"	12000	"	"	"	"	16200					52000
1832°F	1	11250	6750	7800	0.45	0.548"	1.015"	0.243	1.13	8810	0.548"	0.265"	0.930	1.64	12800	0.548"	0.078"	3.16	7.15	55800
	10	15600	9300	10740		"	"	"	"	12130	"	"	"	"	17600					76900
	100	23100	13860	16000		"	"	"	"	18100	"	"	"	"	26300					114000
1472°F	1	17500	10500	12120	0.53	0.548"	1.015"	0.286	1.16	12900	0.548"	0.265"	1.096	1.82	22100	0.548"	0.078"	3.72	10.9	132000
	10	23750	14250	16460		"	"	"	"	19100	"	"	"	"	30000					179000
	100	33100	19860	22900		"	"	"	"	26600	"	"	"	"	41700					239000
1292°F	1	26250	15750	18200	0.58	0.548"	1.015"	0.313	1.18	21500	0.548"	0.265"	1.204	1.94	35300	0.548"	0.078"	4.07	14.3	260000
	10	35000	21000	24300		"	"	"	"	25700	"	"	"	"	47200					348000
	100	46350	27750	32100		"	"	"	"	37900	"	"	"	"	62300					459000

Figure 7 — Data illustrating effect of stock thickness upon resistance to compression.

both front and back of the bite. A report,[9] studying these tension effects was recently published and Figure 9 is based on this publication. It is of interest to note that for heavier cold reductions back tension is considerably more effective in reducing pressure than front tension, and with decreasing reduction front and back tension approach each other in effectiveness. These statements apply specifically to this particular set of rolling conditions. This unusual behaviour cannot be simply explained and serves to emphasize the complexity of the flow conditions occurring in the bite. In general, however, it is seen that rolling pressures may be reduced as much as 50 per cent, if high rolling tension is used.

As was mentioned previously, it is possible to calculate the probable existing roll neck pressure from power tests on a mill if certain assumptions are made. From a knowledge of roll speed and power delivered to the work rolls, the actual rolling torque may be accurately obtained and the problem becomes one of establishing

where k would be equal to 0.5. Examining the effect of roll flattening, it is seen that the bulk of the flattening takes place on the delivery side of the vertical diameter so that for the flattened condition the equivalent center of pressure shifts closer to the vertical diameter and as the flattening effect increases the pressure center more closely approaches the vertical diameter. In effect, this means that k in the above formula is continually decreasing for each successive pass. Tension applied either front or back shifts the pressure peak either forward or backward, front tension shifting the resultant pressure back towards the start of the bite and back tension shifting the resultant point forward. This shifting unbalances the pressure so that the factor k may either increase, decrease or remain as 0.5 on the rigid contact basis. Another important phenomenon which affects the value of k is "piling up" of the metal ahead of the calculated rigid contact chord. Cobbles on hot mills have shown that pronounced "piling up" does occur especially on the thicker slabs, but no physical evaluation

of the extent of this piling up has apparently been attempted. The physical significance of this phenomenon is that the actual contact length under pressure is greater than the rigid contact chord with the excess length all occurring on the entry side of the bite. Consequently, the true center of pressure is at some value greater than 0.5 times the rigid contact chord and values of k greater than 0.5 should be obtained.

Another important factor to be considered in using torque measurements in rolling pressure calculations is the division of rolling torque on the work rolls between useful deformation torque and useless friction torque. This division may be expressed as follows:

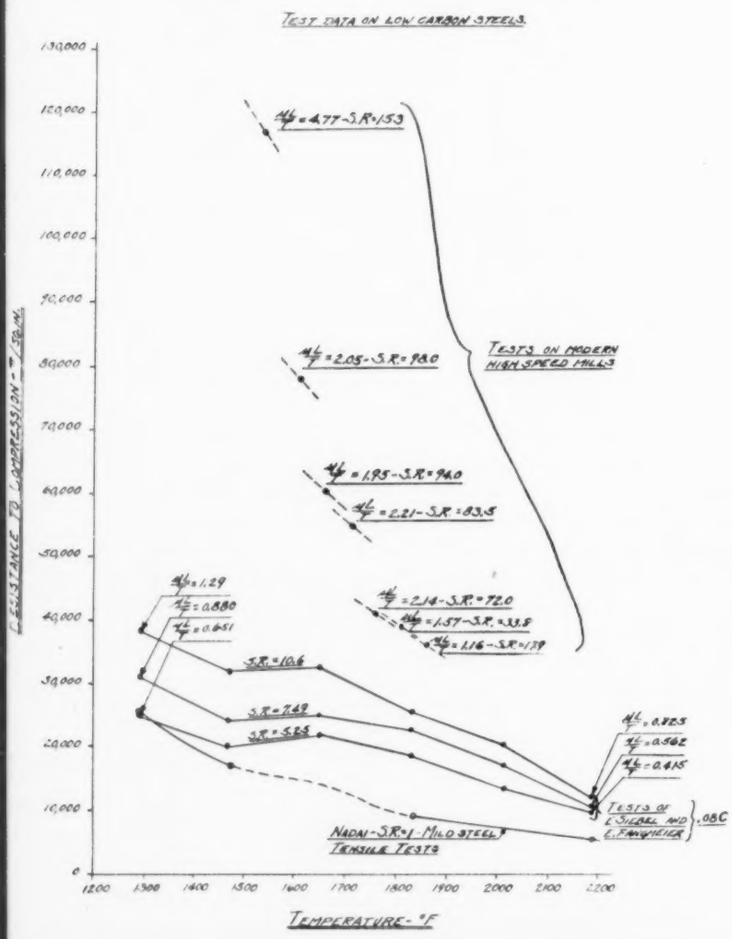
Total rolling torque = deformation torque + friction torque

$$2xpxkxx = 2xpxk_dxx + 2x\mu xpxR'$$

from which $k = k_d + \dfrac{\mu R'}{x}$ ..... (9

where p = total roll pressure, lb
k_d = distance factor
x = rigid contact chord, in.
μ = coefficient of friction of bearing = .005
R' = radius of bearing, in.

Figure 8 — Test data on resistance to compression in hot mills.


TEST DATA ON LOW CARBON STEELS
RESISTANCE TO COMPRESSION - P/2bL
TEMPERATURE - °F
TESTS ON MODERN HIGH SPEED MILLS
NADAI - S.R.=1 MILD STEEL TENSILE TESTS
TESTS OF C. SIEBEL AND C. FAWCETT

Observe that the friction torque is dependent only on the total pressure, while the deformation torque depends on the actual reduction being taken as well as the total pressure. The previous remarks concerning k are really concerned with that portion of k, defined by k_d above. It is seen that k varies further with $\dfrac{\mu R'}{x}$. That this latter can be important is apparent from the several following examples: On say 16 in. diameter rolls, with 12 in. diameter bearings, assuming $\mu = .005$ and $k_d = 0.5$; and further, assuming the small reduction (for hot or cold reduction) of .002 in., resulting in $x = 0.126$, we see that $k = 0.50 + \dfrac{.005x6}{0.126} = 0.50 + 0.24 =$ 0.74. The discrepancy between k_d and k is even greater in skin passing, where, for example we assume a normal 2 per cent reduction on 0.0090 in. strip, making $x =$ 0.038 in., and $k = 0.50 + \dfrac{.005x6}{.038} = 0.50 + 0.79 = 1.29$. Thus the smaller the reduction the greater the effect of neck friction losses and hence it is evident why k can be and is very often greater than 1.0.

Roll flattening, tension, piling up and the actual division of torque are, therefore, important factors entering into the establishment of the correct value of k to be used and if reasonably accurate results are required for a specific rolling condition, it is suggested that actual pressure measurements be made rather than depend on calculations from power tests.

Correlation of simultaneously obtained power and pressure readings for various rolling conditions shows the extent of the variation of the k factor. In several test runs, the roughing passes in a semi-continuous hot mill yield values of k from about 1.0 to about 0.6, apparently decreasing gradually with decrease in thickness. In the finishing stands, k varies from 0.55 to about 0.30 decreasing with decreasing thickness. In regular cold reduction schedules of tin plate gauges, k varies from 0.65 to about 0.25 decreasing gradually in successive passes. Tests on skin passing of tin plate yield very large and widely varying values of k, from about 0.85 to about 6.0! It becomes clear, therefore, that pressure calculation from power readings is not an accurate procedure.

Summarizing, there are five major factors which influence the required pressure for any rolling condition:

1. The material being rolled.
2. Temperature.
3. Speed of deformation.
4. The $\dfrac{\mu L}{T}$ ratio.
5. Tension.

The effect of each has been explained and none can be neglected if reasonably accurate pressure predictions are to be made. Examination of available pressure data shows good agreement between properly calculated and measured pressures. The indicated steps of calculation are from a known constrained yield strength as determined by tensile tests for the given temperature and

rate of deformation to the required specific pressure for the existing $\frac{\mu L}{T}$ condition with trial and error methods of calculation being involved because of roll flattening.

The practical significance of these factors may be seen by examining typical rolling data. Figure 10 shows specific pressures, uncorrected for roll flattening, which are averages of test figures obtained when rolling on continuous or semi-continuous hot mills. Observe that when rolling mild steel on these mills with work rolls ranging from 20 to 27 in. diameter, the required specific pressure seems to approach an asymptotic condition at a thickness in the neighborhood of .050 in.; when rolling Corten the asymptotic condition is at a thickness of about 0.100 in.; when rolling 18-8 the asymptotic condition is at a thickness of about 0.150 in. Varying the rolling conditions such as increasing number of stands, increasing temperature, lowering speed, and also using smoother work rolls, would reduce these limiting thicknesses but for present practice these vaues represent average practical limits.

Another and more striking example is skin passing or temper passing. In temper rolling of auto body grades, when taking about 1¾ per cent reduction on .038 in. thick strip and using a lubricant which is permissible in this case, measured rolling pressures are about 7900 lb per in. of width, which means about 93,000 psi, based on the rigid contact chord. When dry skin passing tin plate gauges below .010 in. with the steel having about the same yield strength as the auto body grades and taking reductions of less than 3 per cent, rolling pressures have been noted above 75,000 lb per in. width of the strip which means above 1,000,000 psi based on the rigid contact chord.

Still another operating phenomenon is that observed on a tandem cold mill rolling low carbon tin plate stock. With a given screw setting, lubrication, etc. gauge of the strip will be found to vary with speed, increasing if rolling speed is decreased and decreasing if rolling speed is increased. This unexpected behaviour is contrary to the usual relationships for all other ranges of rolling. It is evident that increasing the rolling speed with a given set of mill conditions will result in higher localized temperatures in the plastic regions in the bite of the rolls. This increased temperature has two effects: first, the increased temperature will directly decrease the required deformation stress to some extent and second if the localized temperature should reach the range between 400 to 900 F, it is seen in Figure 3 that with increasing rates of strain in this range of temperature a decrease in ultimate strength and therefore required deformation stress takes place. With less pressure being required, the mill flexibility allows contraction of the housing posts and the rolls "sink in" and take a bigger bite and the apparently contradictory fact is explained. Present commercial types of electrical control, such as "tapered tension" control on tandem tin plate mills attempt to correct for this behaviour by having increased tension during periods of lower speeds and decreased tension during periods of higher speeds.

The theoretical advantages to be obtained by modification of some of the factors affecting roll neck pressures are not always to be realized because of compen-

(*Please turn to page 72*)

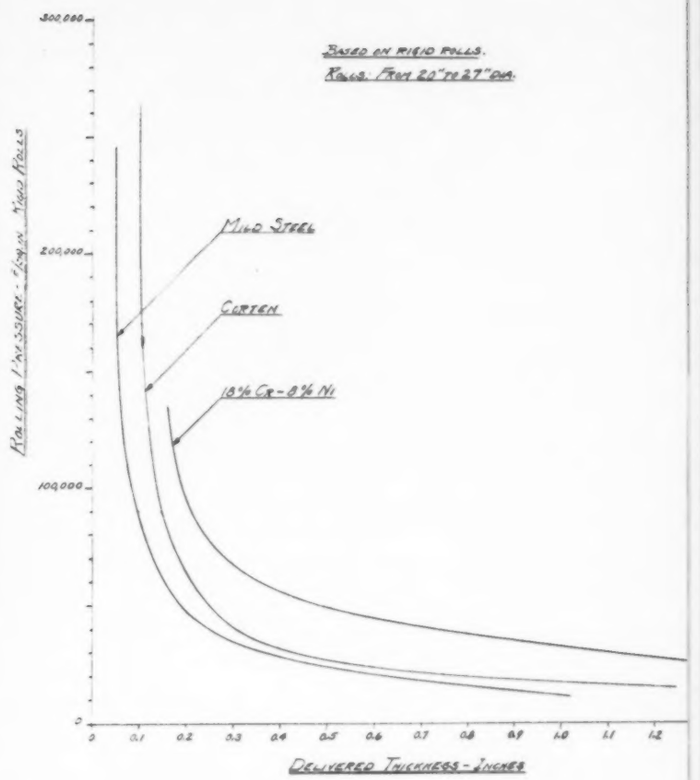
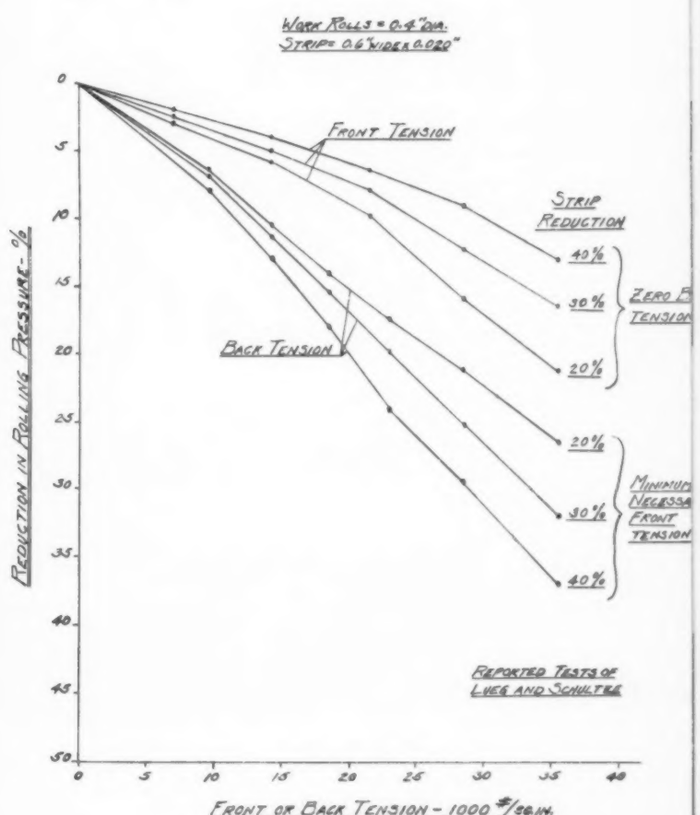


Figure 10 — Observed rolling pressure variation in hot mills with different delivered stock thickness.

▲

Figure 9 — Curves showing reduction in rolling pressures caused by tension.



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"We have now standardized on BUSS Super-Lag fuses throughout the mill as this is only one of several instances where we have cured expensive shutdowns on similar circuits. We could hardly afford to use any other fuse."

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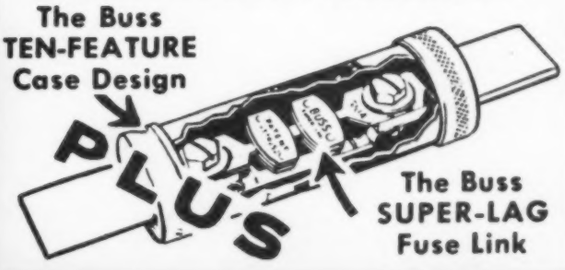

sating practical disadvantages. This might best be illustrated by attempts to use smaller and smaller rolls with their relative advantages and still take heavy reductions at high speeds. The problems of bite angle, removing heat, maintaining good roll surface and having adequate mechanical strength in the roll all serve to make some practical balance necessary.

In special cases, unusual phenomena may occur to cause unexpected pressures and it may be well to amplify on some of these conditions. When cold rolling very thin hard strip, it is possible that the "sinking in" of the strip into the roll bodies, due to deformation of the rolls, will cause the ends of the roll bodies beyond the edges of the thin strip to come into intimate contact so that useless pressure will be exerted just to deform the ends of the roll bodies. The useless pressure can be calculated for any given rolling condition.[9]

Another peculiar rolling phenomenon is concerned with the physical limit to which strip can be reduced on a given mill.[11] The condition has been observed where running down the screws did not increase the reduction, whereas, running up the screws and relieving the pressure has actually resulted in thinner material. To get a physical picture of what is occurring here let us imagine a mill with large diameter work rolls. If the rolls are run together under high pressure with no strip in the mill a flattened region of contact will result and the width of this region of contact will increase with increasing pressure. If now, with the rolls together under high pressure, very thin strip should enter between the rolls, the existing ratio of $\frac{\mu L}{T}$ would be numerically high and the resultant required deformation pressure as determined from the $\frac{\mu L}{T}$ ratio can be so great that it will exceed the roll material's ability to resist deformation and the rolls will deform rather than the strip. This state is defined by the fact that the mill pressure is less than the strip deformation resistance. Imagine the rolls are now run apart with the thin strip still in the mill and it it seen that as the pressure between the rolls is decreased, contact length L decreases and the strip deformation resistance will decrease rapidly because of the exponential character of the $\frac{\mu L}{T}$ effect. When this decrease in strip deformation resistance becomes enough greater than the accompanying decrease in mill pressure so that the actual strip deformation resistance becomes equal to or less than the actual mill pressure for the above mentioned movement of the screws, then the strip will be reduced. And thus it is seen how strip which, for a given set of mill conditions, cannot be reduced by running down the screws may be further reduced by raising the screws.

The aim of this paper has been to attempt to explain the large discrepancies between the physical properties of the strip being rolled and the pressures actually required to reduce the strip. The rather good correlation between observed pressure and the quantitative prediction of pressure is assurance that we are approaching the time when it can be said that this subject is out of the empirical domain, and on a real engineering basis.[12]

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(11) How Thin Can Strip Be Rolled — J. D. Keller — Blast Furnace and Steel Plant — October, 1937.

(12) Since this paper was originally delivered, but prior to its present publication, another article has appeared — Roll Pressure in Rolling Steel Strip by J. D. Keller in "Steel" September 14, 1942, that develops some of the same points made in this paper. The agreement is general and emphasizes again the large effect on rolling pressure friction between rolls and strip, roll flattening and the ultimate thinness — as reflected by the $\frac{\mu L}{T}$ ratio.

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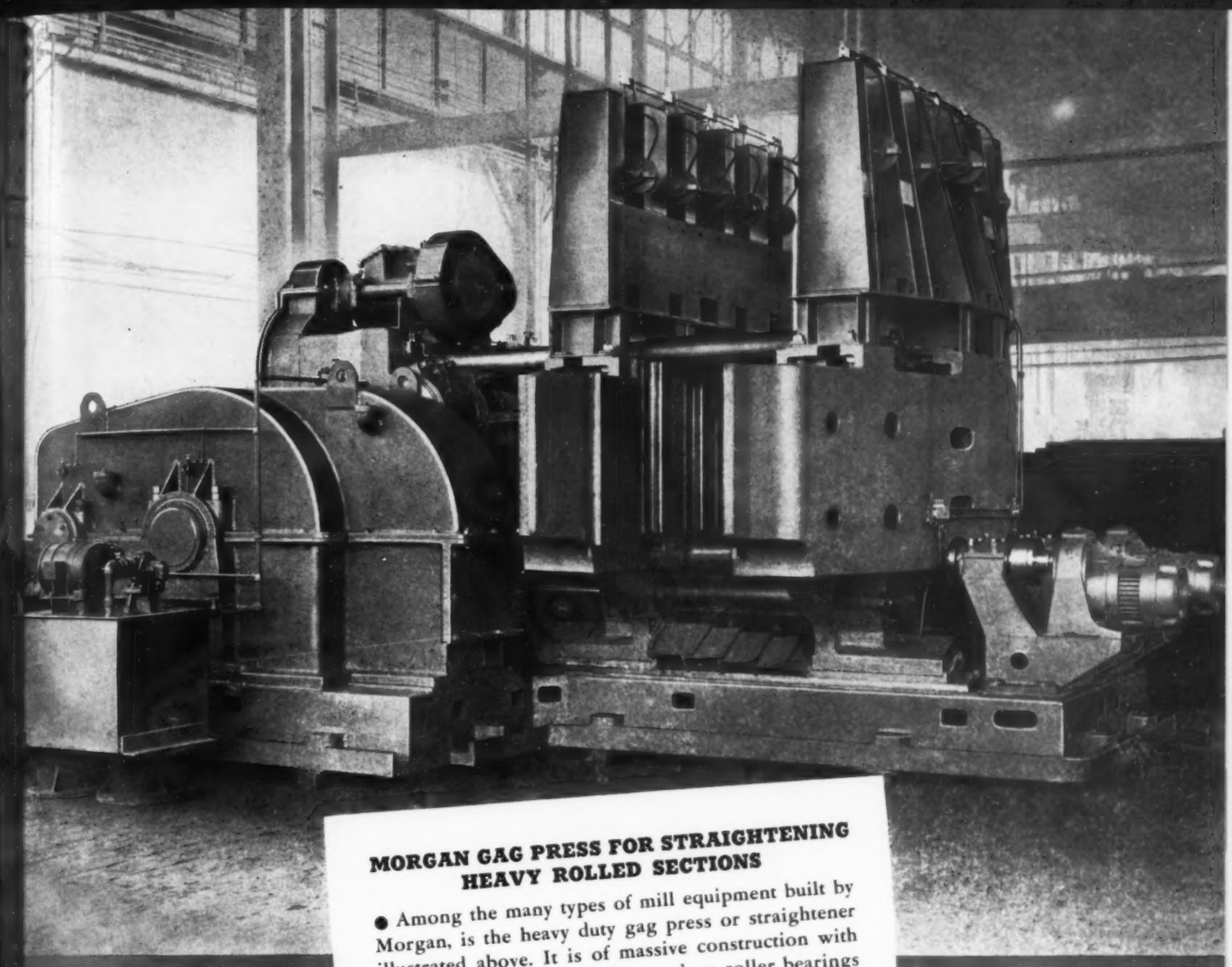

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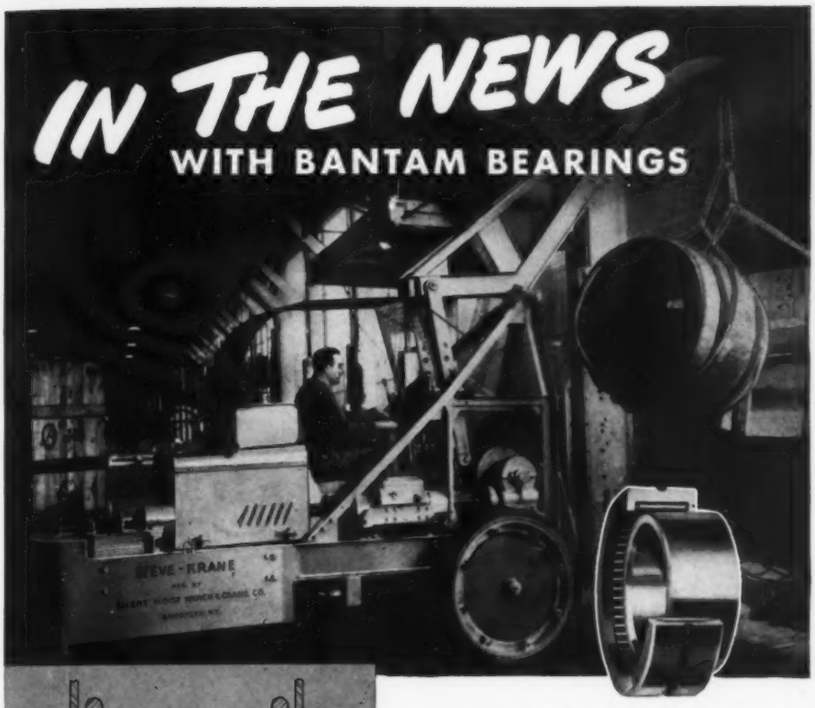

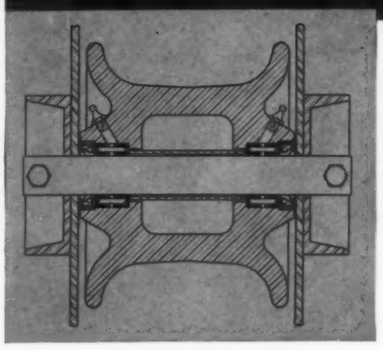

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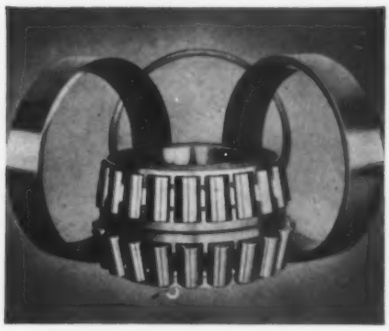

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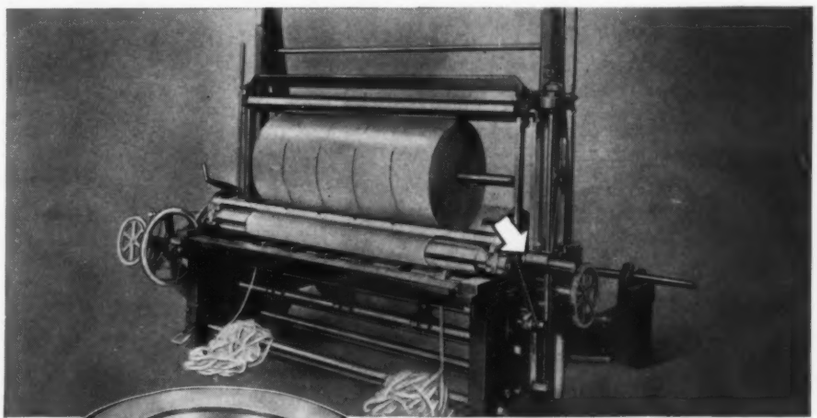

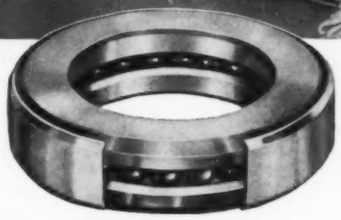

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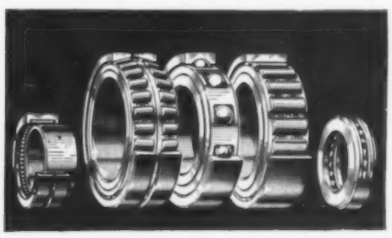

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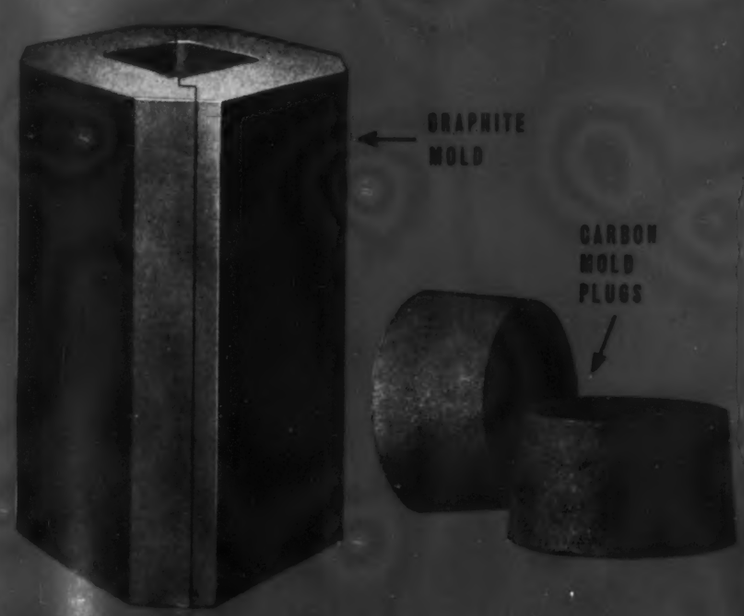

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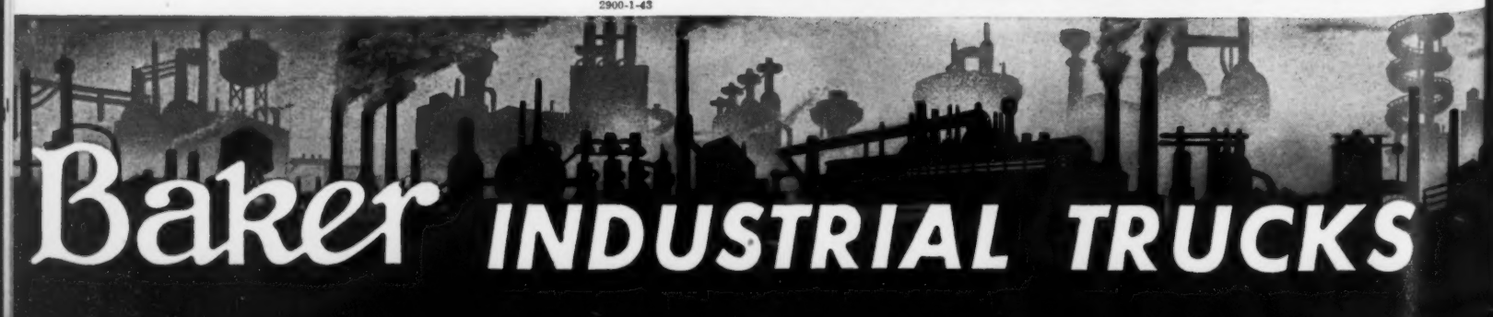

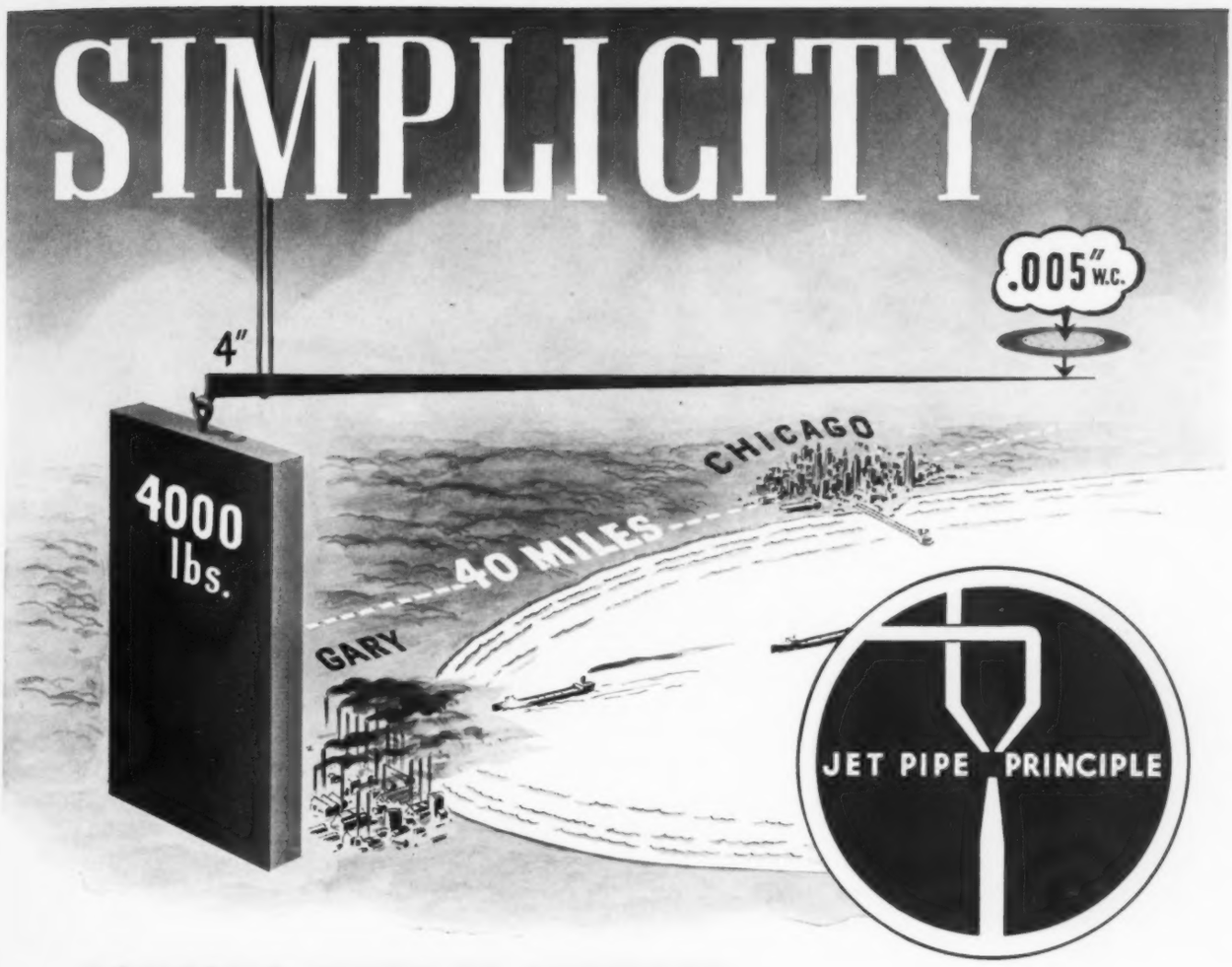

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If you are striving to meet and beat the pledges made to Uncle Sam and would like to learn how these "extra" lubricants listed below can "keep 'em rolling", ask the Houghton Man

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High-film-strength, polymerized STA-PUT Lubricants • Dynamo-Turbine-Compressor D. L. Absorbed Oils • Fortified film, stable, "High-V. I." Hydraulic Oils • Reversible, smooth Absorbed Oil Greases for Ball and Roller Bearings • E. P.-treated Spindle Oils • Stable, strong Diesel Engine Oils • E.P.-treated Gear Oils, and many others for 24-hour War Plant Duty.

* This ad was prompted by the very noteworthy article appearing in this issue entitled "Lubrication Goes To War", by Mr. C. E. S. Eddie, Lubrication Engineer, Great Lakes Steel Corp. We suggest you read it carefully.

E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Lubrication GOES TO *War*

. . . . outlining the position of lubrication and the problems imposed upon it by our all-out war effort . . . .

by C. E. S. EDDIE

LUBRICATION ENGINEER

GREAT LAKES STEEL CORPORATION

ECORSE, MICHIGAN

▲ THE war in which we are now engaged is without parallel in recorded history insofar as it is a war being fought with oil — for oil. The strategy and aggressive movements of the war in Europe so far carried out by the Axis proves conclusively that their urgent need is oil. The hungry Nazi war machine is now moving towards the oil fields of Asia Minor.

Without crude oil, modern lubrication would become destitute. It is the function of our steel and metal industry to provide material for the equipment which uses the energy in oil. Steel without oil is only a barrier. Oil without steel is undirected energy. Oil and steel together provide the components of victory.

Our steel mills are working at their peak capacity turning out plate for ship and tank fabrication, shell stock, and many other necessities used in time of war. It is necessary to maintain a needed wartime capacity of 90,000,000 tons in the steel industry. That's a "mess" of heats. It means every last piece of steel scrap we have and an enormous rolling schedule for a production year. This production of steel is only about 30 per cent more than the tonnage produced in all the Axis dominated countries. Under the present expansion plans and changes in existing equipment, our output during 1943 will be close to one hundred million tons.

Each month now is creating new records in the steel mills of the country. Using an uninterrupted "free competitive system" in producing the American way of life, we have a strong foundation for developing an ultimate force combined with production output that can certainly result in nothing short of final victory in our present global war.

Presented before A. I. S. E. DETROIT District Section Meeting, November 10 ,1942

In the present emergency, every plant is discovering the limits of production, either in rolling or melting, and, strangely enough, is finding ways and means every hour to change equipment speeds and design to meet the demands for increased capacity. However, of equal importance with the metals being used in present-day warfare, is petroleum oil and its many derivatives, acting not only within our industry throughout the nation but as the moving force for battleships, airplanes, and all types of mechanized equipment guarding our home and foreign battlefronts. It is the prime essential of movement. Lubrication for war is part and parcel of the war effort, and therefore the utilization of the products both in industry and on land and sea must necessarily be in accordance with the most efficient development and stable practice.

In the development of the world's natural resources, the engineering profession has been playing a leading part in discovering the needs and developing the many uses of our most important natural resource at present — *oil*. Germany has never been known for any "wildcatting" technique in finding out how much of this omnipresent oil lies under her feet. The petrology of rocks seem too deep to be drilling down 8,000 feet to find out.

Oil is invaluable to organized society, not only as a fuel and lubricant, but as a source of light. It is the raw material for countless products and is used in the smelting of metals from their ores. The hue and cry of the aggressor has been that they were forced into war to gain resources in oil in order to maintain their industrial plants: This is not true. Crude oil in the world prior to this conflict was generously and too lavishly distributed.

The lifeblood of modern mechanized war is petroleum: heavy oil for driving battleships and cruisers, fuel oils

for submarines, gasoline for tanks and fighter planes, etc. All mechanized fighting equipment must be lubricated with petroleum oils for which in present emergency there are no substitutes.

At present, the lubricating oil fraction for industrial and war equipment of the Axis is proving to be a serious problem. Animal and vegetable oils are being substituted with unsatisfactory results. Oil taken from the crank cases of German planes is officially reported to be in a condition no longer considered "safe practice."

The present United States production of crude oil is 4,000,000 barrels per day, and the strange part about this production is that only approximately 5 per cent of this amount, or 200,000 barrels per day, is being extracted for lubricants. It is interesting to note that

Figure 1 — Diesel locomotives, widely used in steel plant service, present a problem of lubrication and filtration vital to satisfactory operation.

this small percentage is more than the total production of crude oil in Germany proper. A unique responsibility, therefore, rests on the lubrication men of this country to supply proper lubrication for the billions of dollars worth of machinery and equipment which is now involved in war and industrial production, the importance of which is evidenced in the spending of over one-half billion dollars annually for lubricants alone.

In order to thoroughly develop this interesting subject, it will be necessary to move rapidly from one study to another without any characteristic connection or transition. If the science of applied lubrication were unknown, there would be no industry. No bombs would be dropped, no ships could be sunk. *There would be no war* However, as conditions are at present, we are forced to sublimate our activities in lubrication and fighting equipment in the preparation to meet the monster of Europe in the only language that he can understand. We are suddenly forced to use years of peaceful striving in engineering efficiency to pit our fighting men and machines against this monster who, in turn, has utilized similar agencies, and who has been allowed to build up a terrific war machine over the past fifteen years.

Looking further back than this into the dark ages, we find that the fellow who invented gunpowder literally tore apart the old feudal system. In like manner, history will verify that what we are doing here in Detroit at the present time will be the gun powder of the "new order."

The records disclose from the earlier centuries that more than 60 per cent of the time was involved in fighting, whereas during the last one hundred years the percentage is less than half of this amount. But notice one thing in particular. That which is being gained by smaller amounts of time devoted to war is being offset by extreme intensity of war and its consequent suffering. You might ask, "What has this to do with lubrication?"

In World War I our scientific progress in engineering and developments in lubrication, crude and fundamental though they seem to us now, accounted for better than 10,000,000 lives, and prior to the period dating from the French revolution less than half this number were killed. The economic losses of World War I, apart from the sacrifices of human life, the cost, and expenses, are still being incurred. In order to present this aspect in our particular study, such developments have accounted for the conditions under which wars are fought today and must necessarily involve good effective and economic lubrication, the design of all manner of equipment, purifying and recovery systems, and, in short, everything that is responsible for cutting costs in production and products of the Allied industries supporting the armament program. Now we are engaged in a great war testing the might and power not of man but of machines for the destruction of themselves and of human life.

Lubrication today has accomplished, whether in the steel mill and factory, or in the battleline, an important objective that the average engineer and layman neglects to recognize. In doing our tasks, one encounters experiences about which many people would like to know. Today, as never before, it is a necessary duty to organize oneself and inject the importance for this objective function in lubrication for every government-producing plant. It is apparent then that dealing with the subject of this order we cannot sit down in the corner and make a specialty of any particular application, as is ordinarily the case for a lubrication study. There never was a period more vital in production than is ours today in maintaining the oil film for war.

In this world battle for power in the plant or in the battlefield, time will indicate very definitely the futility of the aggressor nations to force us to mechanize and fight in this war effort of power to conquer.

Our business now in lubrication, under national emergency as applied to the industry, is one of total war.

We should insist that lubricants be kept under careful supervision; the contamination of oils and greases by the saboteur must be prevented; protective lubrication, both in storage and in large oil circulation systems together with high-pressure, automatic grease systems

is of strategic importance; vital departments and equipment tanks should be kept under lock and surveillance. The plant, in general, is best protected by a loyal organization. In this respect, we find ourselves most fortunate.

In the disbursements of these lubricants, we consider the variations of design and rolling mill equipment and finishing machinery; then literally, the worth and ability of the operating personnel. Neither one can produce without effective lubrication.

The efficiency of movement and operation in the steel mill or in the battleline will be only as good as its lubrication. This influence of success permeates both organizations involved. We have often said if a piece of equipment is properly maintained and lubricated it will never wear out. This is fundamental in principle, but is the greatest factor and handout that the steel business can give to every producing industry.

The design developments through lubrication have not been in many quarters thoroughly appreciated. This study will definitely illustrate what it has done, what it is now doing, and what lies ahead. Many times lubrication is blamed for sins which are ominous.

We never deliberately imply that lubricants cannot fail. They do, and sometimes very seriously if not chosen with care, or particularly if subjected to conditions which they have not been prepared to meet.

It is not generally known, but in the majority of cases lubrication engineering in larger organizations is regarded as a necessary evil. In an average steel plant, $200,000 per year are spent for lubricants. There was a time when no regard for lubricant was considered. Several years ago as I remember it, not as much enthusiasm was indicated for the lubricant as there was in the selection of color for the paint applied to the outside of the equipment. This war has done much to awaken the operating personnel to a realization that continuous production of war materials is essential. There is no time now to haul equipment apart and put it back together again. For many years there has been a widespread misunderstanding of lubrication and its application. The average layman in the mill or factory is now interested and definitely wants to know what constitutes good, protective, and efficient lubrication. It is our job as trained engineers to tell him.

The bibliography of the lubrication art is to the average man much too obscure in equations, atoms, arcs of contact, soaps and sulphurs, etc. He is inextricably too much a unit of the production schedule to allow himself to become involved. On the other hand, you will agree with me that there does not exist on any company's payroll a lubrication expert who knows all of the characteristics peculiar to a particular gear or bearing in his plant better than the conscientious men who watch them twenty-four hours in a wartime day. The psychology, therefore, is that through our experience we supplement our knowledge as an art; to do this requires tact and the close cooperation of these men.

We have lost many of our men in this work through induction to the armed forces. Many of them are using their training and experience to advantage for Uncle Sam.

It is probably most natural for the majority of people to consider the subject of lubrication in terms of their own private automobile. Ever since the hypoid gear design, the age of greater sliding velocity in automobile lubrication, the steel industry has been setting a fast pace in extreme pressure developments for all of the industries. Probably in no other business can one find more varied and complex lubrication problems than in the steel mill with heavy and massive equipment and the adverse conditions under which it has to work; this provides a veritable laboratory for total war on the elements and materials used in machine design. Power absorbed in overcoming friction varies with the type of plant and design of the equipment. It is seldom less than 5 per cent and often greater than 30 per cent of the total power developed.

Prior to the present war period, the continuous mills throughout the country were rolling an average of 550 miles of strip steel about 3½ ft wide every twenty-four hours at a delivery speed of around 2000 fpm. Many things had to be done. New plate lines were installed to handle the changeover from this condition to armor and miscellaneous plate sizes. The steel industry was cushioned and prepared for changes of this type, having had years of experience in engineering design of heavy-duty equipment used in converting iron ore to finished steel products; and now armor plate, shell stocks, and many shapes necessary for war needs have literally replaced this ribbon of peacetime steel.

In the September, 1942, issue of the *Iron and Steel Engineer*, E. T. Weir, of National Steel Corporation, covered very explicity and in good form the new records and changes which have occurred in the plants of the corporation, under the title heading, "Steel's Bid for Victory."

Before the war operating demands were geared to a slower and less exacting pace. Now we are using lubricating oils of greater capacity incorporating high chemical stability. For every 20 F increase in temperature, the chemical reaction is doubled. Consequently, the rate of oxidation is increased. The use of organic and synthetic additives is necessary and is being employed in greater application for extreme service conditions. Therefore, we are selecting lubricants only on a basis that we operate our equipment at highest continuous efficiency and lowest cost.

In reality, production machinery and the methods of its use in recent months have improved so rapidly that ordinary refined or extracted lubricants do not fit the bill. On the other hand, we still have plants and factories operating the same as before the war, although now they are engaged in a continuous war production.

The "lasting quality" of oils in present-day modern usage is the inherent stability or strength in chemical structure of the oil which enables it to withstand the combined destructive effects of high-pressure, speed, temperature, moisture, violent agitation, catalizing, or breaking down when contacting metallic surfaces.

When educating engineers about extreme pressure qualities in oils, we invariably have to draw a comparison between straight petroleum oil and an extreme pressure oil. One of the best illustrations, using our business as a vehicle, is to make a comparison between mild steel and a heat treated alloy steel. By proper heat treating and alloying, the strength and resistance of steel to fatigue are greatly increased. Likewise, by using additives, they increase chemical stability and resistance to deterioration, and the petroleum oil is im-

proved in physical value, and the health treatment is made without sacrificing any quality of the oil itself. The result is that in ordinance applications for Army and Navy, as well as industry, the film strength of the oil is more than double; in some instances it is multiplied as much as six times.

Thus, since December, 1941, lubrication and its definite part in the war program has been steadily growing in its importance and the responsibilities accompanying its recognition. The developments in oils for specific use prior to this period by the manufacturers of extreme pressure lubricants are proving for immediate and necessary use to be of an inestimable value in frontline defense. Today we are treating these lubricants as a component part of the equipment.

Essential engineering for applied lubrication in the industry is as beneficial as the motive power for any machine. We, as engineers, must develop this tendency more often in contacting operators. Upon us rests the responsibility of convincing our associates of its basic value in the solving of lubrication and maintenance problems. Generally, when discussing this subject, we are apt to run into complexities. Use fundamental "horse sense" and avoid high, theoretical values and phenomena. This is wartime, but we must keep our associates in the industries from becoming obscure. We must keep in step with world progress. Practical values of every invention or discovery yet made depend directly upon its being interpretated by the people who have to use it. Therefore, if we are going to gain materially from this study of progress and lubrication under emergency, the interpretation is as important as the creative ability. We accept the values in research as being for the most part authoritative — they advance knowledge. It is our fight to demonstrate this progress. We have definite experience, all of us, that our civilian life advances in direct ratio to the efficiency with which we interpret or convert it into practical usage.

Lubrication is not by any means an "exact" science. There is, in reality, primarily no fixed formula by which we can apply a lubricant to a brand new piece of equipment and have it work 100 per cent. There is no absolute ceiling in perfection. In general academic study we learn about refining processes, sources of lubricating oils, their physical and chemical characteristics. This point I will develop later.

By practical contact in the plant, we gain understanding in the design of equipment, its operation, the application of suitable lubricants, and in many special problems and conditions. As a rule, we generally apply and live through in what is termed the "hard way."

Since I have mentioned refining processes, let us for a moment at least give them consideration. Being American, the production side of the petroleum industry is a familiar subject to the reading public, probably as familiar as putting gasoline into one's automobile at a gas station. Yet, little is printed for public reading regarding the potent facts — refining and development.

Under the hood of each car is the internal combustion engine, which we all profess to know something about. But strange as it may seem, many men we talk with feel that there is something mysterious existing in just putting a few quarts of oil in the crank case. This is fundamentally due to a lack in the understanding of certain facts and properties of the oil itself. The use of petroleum substances have been in evidence in the world for at least 6,000 years. That is quite some time before the first well was drilled for commercial production.

We ride in a train or automobile and take a hasty, occasional glance at industrial romance in a farm of storage tanks, growling stills, pungent odors of sulphurous-smelling crude, or a tangled mess of pipe lines as complicated as though a cyclone had passed through. We naturally shy away from trying to understand the refining processes and its diversity of usage. This is about the time when the man behind the wheel begins

Figure 2 — Required to withstand heavy loads, impact, water and dirt, lubricants for steel plant equipment have been developed to a high degree of satisfaction.

to feel that he does not buy oil but the brain child of the petroleum chemist. There is really nothing complicated in the refining process, whether it be Pennsylvania, Gulf coast, mid-continent, or California. These terms are fast becoming obsolete. The process developed enables refining plants to give us oils of definite characteristics from any crude, regardless of its origin. The paraffinic, naphthenic, and aromatic series provide only a variety of hydro-carbons. Using the two elements carbon and hydrogen, certain numbers of these atoms group themselves together to form hydro-carbon molecules. There are many combinations that these elements can assume to produce numerous products. The hydrocarbon family, known to us from Mother Nature as oil from the earth, can be, if necessary, synthesized using elemental carbon and hydrogen.

There is nothing in processing or in the marketing of lubricants but what is fundamental in value, and the simplicity of this fact constitutes a true basis for our

enlightenment. Distillation, deasphalting, dewaxing, solvent extraction, redistillation, filtration, and blending, all form the major steps of the refining process for the removal of undesirable products, giving us a finished ready-to-use oil from the crude. Proportioning systems have been developed for accurately compounding, blending, and mixing of oils automatically. These oils are so thoroughly mixed that many applications heretofore were not considered possible due to oil separation.

This war has introduced distinctive advances in design and research affording successes in engineering practice that have made their mark in the industries and can, therefore, be applied to the machines of war. This work has not only included fuels and lubricants but also such blends for internal combustion engine use, medicinal compounds, wood preservatives, slushing oils for steel, and recoil oils for guns. The value of this work in wartime equipment is inestimable.

By cracking and refining petroleum products, we can increase the yield of usable products, which can only be accomplished through the use of steel which can withstand high temperatures and pressures. Stills and fractionation towers normally working at 275 psi and 550 F have been increased to 650 psi and 1400 F.

Without oil and its family of relatives, we could not hope to settle any issue in this war. We have behind us 83 years of practice. In 1915, the automobile industry became large enough to demand special lubricants and fuels in great quantities. We are familiar with Detroit and what has happened in automobile design. Automotive engines have almost doubled their horsepower output for the same size motor. In doing this, an effective contribution has been made with concomitant responsibilities on the part of the lubrication engineer.

Coupled with the development over the years, the consistent habits of analyzing conditions, and our ability to look further into that drum of crude oil and its vital essential are now giving us a deliberate advantage in the present war campaign. The next question in line would be, "What about our natural supply of crude oil?"

You will recall that a few years after World War I, there was considerable discussion regarding the supply of petroleum and how long it would last. Geologists were forecasting that the rate of consumption of nearly 3,000,000 barrels per day would last but a few years, and that substitutes would inevitably be necessary. With the advent of deep well drilling, revival of so-called "exhausted" fields, and the spreading of this development into other areas which were heretofore regarded as barren, today the shortage of petroleum for many future years to come is not a matter for immediate concern. The definitely proven sources of crude today approximate 22,000,000,000 barrels and it is reasonable to state that as time marches on we will continue to find this mineral wealth in new places. However, we cannot waste it and win. The lack of conservation for any purpose or application can make the difference that can mean our defeat.

When the assembly lines went down in January, 1942, more than 85,000,000 motor cars had been produced. The tangible symbol of American life before the war was the automobile. Replacing the production of over 4,000,000 automobiles per year and the stepping up of war materials to meet the demand of the government is a mammoth job.

Now it can be said — *we are not converting — we have converted.*

There are many armaments being produced for war, and whether we know it or not this war will depend largely on what we in Detroit, the world's greatest armament center, can produce.

It is true that we are constantly striving for more speed and better quality. The changeover has been so rapid as to challenge the imagination and excite the envy of the outside world. Pearl Harbor was the compelling reason for this changeover. And to put it bluntly, as far as war equipment was concerned this country was in one hell of a mess.

During the efforts of our peacetime period, specialists were developing every article of convenience and ease used in the American household, while during a similar period our associates in the aggressor countries were applying their arts, efforts, and ingenuity to the development and production of munitions, as well as the creation of a stubborn, determined, mental and criminal attitude. They collected stocks of scrap steel and necessary materials for war from under our nose in the preparation of taking from us what we now have. Mass production of machines is the basic success in fighting this war with oil — for oil. Our city has sponsored, as I mentioned earlier, this means towards the aggressor's end, not only because the production line was effective in low cost automobile output, but also because the development of essential lubrication is necessary in changing over the methods being used to produce tanks, guns, planes, and even ceramics and textiles. Lack of adequate machine tools, were to begin with, the bottleneck, and in some instances still are. The rapid and successful expansion of the tool industry is indicated from a cost value — in 1940, $400,000,000; in 1941, $800,000,000; and an estimate for the year 1942 of $1,000,000,000.

The complete change from machine tooling practice to that required in armaments involved highly specialized tools and equipment. This required the necessity for specialized lubricants, as some tools are subjected to pressures as high as 350,000 psi and temperatures of 1000 F and higher. These oils having antiweld properties assure smooth finish and clean cutting and thereby minimize rejects and reduces tool wear, which, in turn, cuts down "time-outs" for tool changes.

In order to appreciate this changeover, a few specific examples of what has been taking place are necessary to illustrate this picture of lubrication and engineering in war production. To begin with, the availability of the automobile industries' tools for producing aircraft engines was not over 34 per cent and averaged 18 per cent. We have evidence of how even the buildings were unsuited for certain changeovers. The result is that we now see new panoramas in building construction. The combined plants of Detroit are now producing and delivering airplane motors, tanks, guns, and war materials more than double their peacetime production peak. This is equivalent to producing over 10,000,000 cars and trucks in a calendar year, and is a tangible means of comparing Detroit's war effort in terms of steel and metal produced, also man-hours consumed. Grooving operations that took 36 hours are now

done in 43 minutes. Drilling operations which required 420 machine minutes are now involving only 9 minutes. Rifle barrels are drillled with speeds as high as 2,000 rpm. In gun fabrication, the 75 mm at one time took 45 hours rifling the barrel; now the time is down to 15 minutes, and the list of similar achievements is endless. These are all children of necessity in our rush for increased war production and are due principally to better lubricating, cutting, coolant, and honing oils, also the quality of steel used for effective tooling. This family is growing rapidly every minute. The picture is changing every day, faster than it can be recorded.

The lubrication engineer's contribution involving piercing, drawing and quenching compounds is a very important factor. Another effective development is the use of continuous pressure and magnetic filtration for soluble coolant and cutting oils. This has signally helped conditions in the operation for circulation systems used with centerless grinders, reaming and rifling processes. They allow removal of finely suspended particles and a return of clean product to the wheels. This has resulted in an average 27 per cent increase in most grinding productions, 80 per cent reduction in the case of the centerless grinders in wheel dressing, and a greatly improved quality and quantity of work.

Let us consider for a moment the aircraft power plant. The progress made in the lubrication and design of this motor must necessarily date back to 1917. For the most part, 200 horsepower engines at that time were using castor oil for lubrication, and fuels of less than 60 octane. They invariably required tearing apart every 50 hours of operation. Today, engines are being produced over 2000 horsepower rating. They are lubricated with highly refined oxidation-inhibited petroleum oils using 100 octane fuels and are capable of continuous running for at least 700 hours. Present commercial airline practice is 20,000 miles between oil changes and 100,000 miles between motor overhauls.

Since this is total war, it was necessary to develop oils operating at from minus 30 F up to 125 F ambient temperatures. Bearing such facts in mind, that reduced atmospheric pressure will also reduce flash and fire points of the oil. The future work along this line will be to control temperatures of various engine parts and give better and more efficient lubrication. The use of additive oils in long-range flying will improve engine cleanliness. However, new developments along this line sometimes prove disastrous when making changes in engine designs, as one oil is lubricating all parts of this same engine.

In recording the Allied nations' aircraft production since the Pearl Harbor event, the output is 30 per cent greater per month than that of the Axis powers. It is estimated that by January, 1943, our air force strength will predominate 2–1. This fact is very encouraging considering our responsibilities here in Michigan in our production of motors and war fabrication.

In World War I, the average tank weighed about 20 tons and had a speed of about 10 miles per hour. Today a medium tank of 30 tons has a speed in excess of 35 miles per hour. The engine horsepower is increased 20 times, with a temperature increase of 100 per cent, and pressures and rubbing speeds as high as 300 per cent. This condition vitally affects the oxidation of the oil. Therefore, it has been necessary to develop an oil with additives and inhibitors which will successfully meet this requirement in service.

Great Britain has contributed much to the developments in lubrication and design from the viewpoint of equipment in war use prior to our entry into the war. It is a known fact that we are receiving such information as fast and as soon as their experiences allow. Ordinarily, this information would not be forthcoming in normal competitive times.

The demand for lubricants in our Army and Navy today can be covered in three main items: first, product; second, application; third, available supply.

The engineering development in steel manufacturing has forced the petroleum industry to refine and market the lubricants to withstand high pressure and temperature treatment encountered in today's demand for mechanized service. Lubricants developed for steel mill use are being found to be very satisfactory. Under very severe conditions, a uniform lubricant body can be maintained. The life of bearings, gears, and imperfect alignments all make demands on a lubricant. It was found that in a great majority of cases regular grades of oil could not meet the situation regardless of their refined quality.

Essential details in design are wholly dependent upon special lubricants and have thus become inseparable parts of the machine design. Practical operating conditions are seldom ideal. Many operating factors are presenting themselves daily all affecting the life of equipment which is so vital to the war effort. The result of metallurgical research has developed alloy steels which will withstand pressures as high as 100,000 psi, high rubbing speeds, and operating temperatures. Straight oils withstand from 10,000 to 20,000 psi. It is indicative, then, from our point of view, that using a treated lubricant capable of taking a pressure of 150,000 psi without seizure of metal surfaces will transmit ten times as much power without increasing the gear size. Or putting it in reverse English, the size of the gearing can be reduced to 1/10 of that generally used in the design of the equipment. The use of sulphur, combined sulphur and chlorine compounds are now being used with animal and vegetable fats to form extreme pressure characteristics. Additives are classified for special purposes and consist of materials from chemically reformed petroleum through vegetable, animal, and metallic compounds. They are blended into specified oils and cannot be wedded to any class of oil. The applications for this type of lubrication are limitless, so extensive are the ramifications.

We must remind ourselves in fighting this war that lubrication problems involve millions of dollars worth of equipment which is, under certain priority ratings, almost impossible to replace. Throughout the country some of this equipment is in a more or less depreciated state, and since it must be by all means kept in continuous service with a minimum of maintenance expense, we must take advantage of all developments in the science of lubrication. The old type equipment must compete with the new until after the war. It should also be borne in mind that any equipment thrown idle due to war production should be preserved by newly-developed petroleum compounds now on the market for the

purpose of rustproofing. These compounds are doing an essential job since the paint supply is limited. Competent authorities have stated that 2 per cent of all steel rolled and manufactured is currently being destroyed by rust. The U. S. Army has recently issued stringent regulations concerning the rustproofing of all spare parts and replacements, especially exports to foreign fronts. This essential is as important as the production of the precision part itself.

Efficiency in lubrication has more to do with successful operation than any other factor involved in costs. It involves many things besides preservation, such as power, replacements, maintenance repairs, labor, operating delays, and right down to the finished product itself.

Many small industries are deprived of materials due to priorities. The subcontracting of work has introduced new problems for large as well as the small companies and has necessarily changed their lubrication schedules and practices. Under these circumstances, the oil companies have rendered valuable service through their policy in serving the plant personnel and, consequently, rendering efficient machine operation.

Figure 3 — Modern equipment is designed with attention to the requirements of lubrication by centralized automatic systems.

Mention should be made regarding the storage and distribution of oils during wartime. Protection in war generally forces us to think of going underground like the groundhog. In our travels on foot next year anywhere along the sea coast, that attractive looking summer cottage, or whatever happens to be there, might in reality be one of our nation's secret stores of military oil supplies buried underground. This is necessary in the event of national emergency. Recommended storage for this purpose is estimated to be between 10,000,000 and 20,000,000 barrels.

The tank farms in peacetimes were designed and built economically with little thought of safety during air raids. If we were ever unfortunate enough as to have an invading force attack and land on our shores, the problem of transporting oil supplies will certainly not be so great as has been evidenced in other nations.

This country primarily is the world's largest producer of raw materials. It is producing refined products well in excess of its domestic requirements. Our Union is covered by a tremendous network of oil pipe lines, for the most part underground, and which approximate 60,000 miles in aggregate extent. Refining operation is scheduled for the production of greater yields of fuel oil and reduced yields of gasoline which, at the present time, is about 10 per cent or more below normal.

In closing, I would like to add that we are striving for a period of equilibrium in balancing the scales against the Axis. We are still on the light side. We know that America has never lost a war; neither has Japan, for that matter. We simply must in sincerity realize that our very existence as free men and a free nation are at stake.

DISCUSSION

PRESENTED BY

C. F. COWLEY, Fiske Brothers Refining Company, Detroit, Michigan

JAMES J. MEEHAN, Lubrication Engineer, The Texas Company, Detroit, Michigan

C. E. S. EDDIE, Lubrication Engineer, Great Lakes Steel Corporation, Ecorse, Michigan

WALTER D. HODSON, The Hodson Corporation, Chicago, Illinois

H. H. BARROWS, Industrial Equipment Company, Detroit, Michigan

V. A. SMITH, Assistant Industrial Lubricating Manager, Socony-Vacuum Oil Company Inc., Detroit, Michigan

D. C. PRICE, District Manager, S. F. Bowser and Company, Incorporated, Detroit, Michigan

C. F. COWLEY: Mr. Eddie's paper covered the field of lubrication in about as fine a style as I have ever heard. Mr. Eddie avoided going into details on specific lubricants and in that way has given us a picture on lubrication that is very interesting and easily understood by the average layman.

The keynote of the speech in my estimation is the fact that more thought is being given to film strength of lubricants. Mr. Eddie spoke a lot, of course, on the oils, but the thing follows through also with the various greases which are lubricants in every sense of the word.

I am very much interested in the high film strength lubricants and feel exactly the way Mr. Eddie does. He mentioned that lubricants were required to withstand a temperature of minus 30 F. It is interesting to note that the aircraft industry is requiring lubricants to withstand minus 70 F and these are being made successfully at the present time.

J. J. MEEHAN: I want to say that I concur in what the gentleman has just said as to the paper on lubrication presented here. However, I would have liked to hear Mr. Eddie elaborate somewhat as to the preservation of the various types of materials from which we are making parts for shipment abroad. I think that that side can stand for a lot of real, good consideration on our part.

I think we are probably all to blame for the fact that while this precision work is done here, we have failed to provide for the preservation of the parts after they have been ready for shipment to the various places in the world wherein our landing forces are.

This point that Mr. Eddie brought out on rust processing is very definite. The army as he has said is now really bringing out stringent regulations in order to cover that particular phase of it. I remember in the last war I had a similar experience. We received parts but we couldn't use them. Parts that are sent abroad without proper rust protection will result in failures.

C. E. S. EDDIE: I would like to make a statement in that regard. During my investigation of this subject I did find this: the very outstanding fact, that in the Burma offensive it was known that the parts received there were so highly oxidized — or rusted as we commonly say — that they were unfit for use. I am referring to tank replacement parts and so on.

Now, this is to me one of the principle indicators why the government and the army are doing what they are today. It seems ridiculous that we should make precision parts and send them to places like Burma and when they get over there they cannot be used.

W. D. HODSON: I have been listening to papers and discussions on lubricants and lubrication for the past 15 or 20 years. In commenting on Mr. Eddie's paper, it covers so many phases of the subject, and in such a very unique and unusual manner, that I find it difficult to know where to start. First I wish to speak of a meeting in New York about 15 years ago of the American Society of Mechanical Engineers, where a paper was submitted on lubrication in which it was stated that the lubrication engineers of this country could be counted on the fingers of one hand, without including the thumb. As I have listened to Mr. Eddie, that meeting of 15 years ago and the above statement has been fresh in my mind and I have been very much impressed with the fact that now we have lubrication engineers in practically every large industrial plant, especially in the steel mills and allied industries, and most of them are truly engineers of the finest type. And it is not confined to lubrication engineers as those more outstanding at least are mechanical engineers, and some of them chemical engineers, also.

One of the finest examples we have of the difference as to lubrication engineers between 15 years ago and now is evidenced in men like Mr. Eddie, who stands out with the top men in his profession. What he has had to say — his viewpoint of lubrication and lubricants — is so wholly different from most of the papers that have been prepared, and the statistical facts that he seems to have at his finger tips — makes me wonder how he has found time, with all his other activities, to gather together such information and present it so well. To me it has been truly astounding, and one of the most interesting I have ever listened to

Lubricants and lubrication is my business. My company's activities are connected with the government, as well as most types of industries. Our thoughts and efforts are directed primarily along the following lines:

1. Designed lubricants that will come more nearly meeting the requirements of the more severe demands than those lubricants in most common use.
2. We have for some time given special thought to viewing lubricant as a component part of equipment, rather than a supply, treating it as one with the mechanical device to be lubricated, thereby designing both the lubricant and the equipment as a unit.

As we all know, it is the general practice to treat the compounding of lubricant as one subject and the designing of the equipment as another, sometimes with little thought as to the suitability of one for the other, except in a general way. This line of thought is emphasized by an assignment recently given to us. This is in connection with a screw and nut used on one of the more important defense units which must operate under a load of 14 tons per square inch under temperatures ranging from 70 F below zero and 180 F above zero. Whoever designed this treated the lubricant and the means of applying it lightly to say the least, as the designing engineers seemingly expected to find a suitable lubricant of the character described which could be applied manually from time to time, and probably with the hope that an application would last over a considerable period. In studying this we found that no provision had been made whatsoever for applying the lubricant, except to daub some on once in a while with a brush or swab. The design provided for the screw to be stationary and the nut to turn. We suggested that this be reversed, designing the screw to turn and with the nut to be located in a stationary position, and of a design to provide a pocket for a supply of lubricant and with a means of feeding the lubricant to the screw as it passed through the nut in proper amounts to maintain lubrication.

Another of our recent experiences was in connection with a tie rod connector of an automobile. I believe it is the common practice to lubricate the tie rod connectors, or supposed to be, whenever the chassis is lubricated or the motor oil changed — about every 1000 miles. In considering this with the engineers of the plant making this tie rod connection, we suggested that we approach the subject with the idea of furnishing a lubricant that would stay put and last the life of the tie rod connection. This was not received with favor, as based on standards established by past practice. The engineers we were discussing it with did not believe it was possible to do what we had suggested. We then offered the thought that we would start by endeavoring to provide a lubricant that would last the average car mileage of the original owner — 18,000 to 20,000 miles. The engineer agreed that would be desirable, but thought it would be impossible. The test was started with two lubricants. From time to

time during the warm weather and the cold weather during the approximate year and a half the test has been run, tests were made to determine the torque, the ease of steering, whether the lubricant was leaking out or not, etc. About two weeks ago, one of the tie rods and its connectors were disassembled. At that time there was approximately 36,000 miles on one of the connectors and some 15,000 to 16,000 on the other. (Two different lubricants were used.) Ample lubricant was found in both the connectors, and the wear was so little that it required microscopic measurements to determine. The wear was so little and the conditions so favorable, that it was voiced that the final mileage of the two connectors left in service should be approximately 150,000 miles. When first checking up on this, and before the parts were taken off the car and disassembled, the opinion was that we could probably expect 60,000 miles.

A similar project now under consideration is in connection with the idler wheel of a tractor, which it is the practice to lubricate when on a hard job every 10 or 12 days. Designs have been developed, and a special lubricant has been designed, to meet the condition, which it is expected will last the life of the idler assembly.

H. H. BARROWS: It is very evident that the lubricating engineers have made marvelous strides in the production of better lubricants. Also, the manufacturers have made marvelous strides in the manufacture of mechanical devices for the application of the lubricants. But, unfortunately, as this gentleman says, the condition is such that in many cases, the designer of machinery designs a machine to accomplish a certain purpose and eventually somebody wakes up to the fact that the machine has to be lubricated. There is also a great propensity on the part of the buyers of machinery to buy a piece of machinery without ever asking, "How is it going to be lubricated?" You find that people buy cranes and other production machines and you ask them, "Have you covered the lubricating equipment in any way?" The answer is, "Oh, no, just the standard stuff," without any regard as to whether that particular set up is capable of fulfilling the requirements at all, or whether it is efficient.

While we are not now talking to machine designers primarily, we are talking to operating men out in the shops. The operating men can do a lot in the right direction by investigating not only the proper lubricant to be used in the machine, but also the method of application that is being provided by the machine builder, before he buys a piece of machinery.

V. A. SMITH: When I saw the subject assigned to Mr. Eddie I wondered how he was going to handle it, because you can get off on a tangent and go into a great deal of detail which would not be interesting to a group of this size. The field is so large that one can become lost in it very readily.

When I think of the comparison that he has made between conditions in the last war and the present one, I am reminded of an advertisement which was used some 20 or 25 years ago by one of the major oil companies. It showed the globe with two poles extended as axes. These were supported by two bearings and the caption of the print was to the effect that the world rotated on a film of oil. Today this statement is still true, but due to conditions the world has become unbalanced and the load, instead of being light or normal, is now one of continuous shock and high pressure. The film of oil needed today is one having the extreme pressure qualities which Mr. Eddie has mentioned.

It is true the mechanical engineer has become a very important factor in the development of lubricants, but the time has passed when he alone can take the plume. Today the chemist has entered into the picture and has had more to do with the actual development of products than the mechanical engineer. The lubricating oil part of the petroleum industry is founded on chemistry. The straight mineral oil, as Mr. Eddie has remarked, is rapidly passing out of the picture for many applications. It is just as out of style as the oils you fellows used in the old hot and cold hand mills — those, of course, were a black oil, red engine oil, and a cylinder oil. The lubricants which have been developed are so different and the requirements for which they are used are such that the old products wouldn't stand the gaff. As a result, these extreme pressure types of lubricants have come along very rapidly.

So, as Mr. Eddie has said, the progress of lubrication and, indeed, the progress of the world, still revolves around a film of oil.

D. C. PRICE: We talk about precision equipment and its manufacture in this day and age. For instance, it has been found very advisable to utilize special equipment that removes dust from oil which in turn is used to wash ball bearings during their manufacture. This dust is so fine it is microscopic and indicates the protection given vital machining and polishing of these bearing parts.

While we are thinking about precision equipment, this illustration might interest you. No long ago we received a naval contract for the manufacture of automatic fire control boxes. This precision equipment automatically compensates for various factors and variations in firing a gun on a battleship. Thus, all gears and parts must be finely precisioned in their manufacture. It was not unusual, therefore, to understand why the drawings as supplied us by the government indicated that tolerances were to be "plus or minus zero."

LOFTUS ENGINEERING
corporation
1620 OLIVER BUILDING PITTSBURGH, PA.
BRANCH OFFICE
519 HOLLINGSWORTH BLDG. LOS ANGELES, CAL.
Engineers — Consultants — Contractors
Designers and Builders
of
MELTING • HEATING AND
INDUSTRIAL FURNACES

The eyes of all America are upon the United States Treasury Roll of Honor appearing in the "Payroll Savings News." For copy write War Savings Staff, Treasury Department, Washington, D. C.

HOW TO "TOP THAT 10% BY NEW YEAR'S"

Out of the 13 labor-management conferences sponsored by the National Committee for Payroll Savings and conducted by the Treasury Department throughout the Nation has come this formula for reaching the 10% of gross payroll War Bond objective:

1. ***Decide to get 10%.***
   It has been the Treasury experience wherever management and labor have gotten together and decided the job could be done, the job was done.
2. ***Get a committee of labor and management to work out details for solicitation.***
   a. They, in turn, will appoint captain-leaders or chairmen who will be responsible for actual solicitation of no more than 10 workers.
   b. A card should be prepared for each and every worker with his name on it.
   c. An estimate should be made of the possible amount each worker can set aside so that an "over-all" of 10% is achieved. Some may not be able to set aside 10%, others can save more.
3. ***Set aside a date to start the drive.***
4. ***There should be little or no time between the announcement of the drive and the drive itself.***
   The drive should last not over 1 week.
5. The opening of the drive may be through a talk, a rally, or just a plain announcement in each department.
6. Schedule competition between departments; show progress charts daily.
7. Set as a goal the Treasury flag with a "T."

AS of today, more than 20,000 firms of all sizes have reached the "Honor Roll" goal of at least 10% of the gross payroll in War Bonds. This is a glorious testimony to the voluntary American way of facing emergencies.

But there is still more to be done. By January 1st, 1943, the Treasury hopes to raise participation from the present total of around 20,000,000 employees investing an average of 8% of earnings to over 30,000,000 investing an average of at least 10% of earnings in War Bonds.

You are urged to set your own sights accordingly and to do all in your power to start the new year on the Roll of Honor, to give War Bonds for bonuses, and to purchase up to the limit, both personally and as a company, of Series F and G Bonds. (Remember that the new limitation of purchases of F and G Bonds in any one calendar year has been increased from $50,000 to $100,000.)

TIME IS SHORT. Our country is counting on you to—

"TOP THAT 10% BY NEW YEAR'S"

EVERYBODY EVERY PAYDAY AT LEAST 10%

Save with
War Savings Bonds

A. I. S. E. District Section Meetings

BIRMINGHAM, MARCH 30th

"Remodeling the T. C. I. Plate Mill," by J. D. Clark, Chief Draftsman, Tennessee Coal, Iron and Railroad Company, Birmingham, Alabama.

CHICAGO, MARCH 2nd

"Symposium on Maintenance Conservation Practice," Group discussion.

CLEVELAND, MARCH 15th

YOUNGSTOWN, MARCH 16th

"War-time Bearing Metals," by H. L. Smith, Federated Metals Division, American Smelting and Refining Company, New York, New York.

DETROIT, MARCH 9th

"Maintenance Symposium," Chairman, J. A. Shimmin, Superintendent of Maintenance, Rotary Electric Steel Company, Detroit, Michigan.

PHILADELPHIA, MARCH 6th

"Reclaimed Sewage Water for Industrial Uses," by L. F. Coffin, Mechanical Superintendent, Bethlehem Steel Company, Sparrows Point, Maryland.

"Palm Oil Control for Cold Mills," by C. E. Duffy, Assistant Fuel Engineer, Bethlehem Steel Company, Sparrows Point, Maryland.

PITTSBURGH, MARCH 8th

"Power Interconnections Between Steel Plants and Utilities," by B. M. Jones and H. W. Dexter, Jr., Duquesne Light Company, Pittsburgh, Pennsvania.

★ ★ ★

A. I. S. E. Spring Conference

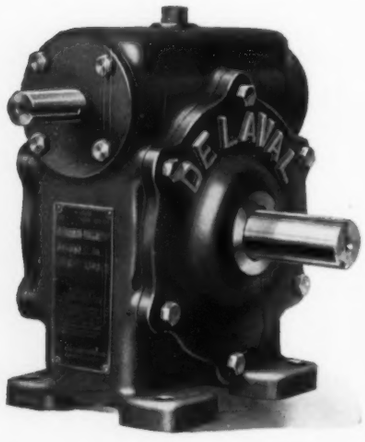
MONDAY, MAY 10, 1943
William Penn Hotel
Pittsburgh · Pennsylvania

★

This meeting is under the auspices of the newly formed ROLLING MILL COMMITTEE of the Association of Iron and Steel Engineers. In this initial meeting, discussions will deal with blooming and slabbing mills, including soaking pits, mill drives, mill design, rolling schedules, and treatment of product.

SMALL WORM GEARS FOR VARIOUS DRIVES

▲ A great variety of motor-driven industrial equipment, such as mixers, dryers, automatic furnaces and ovens, churns, small conveyors and elevators, mechanical stokers, door openers, etc., requires only small power, but, as small electric motors run at high speeds, speed reducers are necessary. The small worm gears here shown are produced by the De Laval Steam Turbine Company, Trenton, N. J., for ratios of 3⅝ to 1 up to 60 to 1 in 3 inches and 3½ inches center distances. They are distinguished by having casings cast in one piece, the casing with side plates totally enclosing the working parts and serving as an oil reservoir from which the bearings and gear teeth are lubricated. The interior is accessible upon removing one of the side plates, although the only attention required is checking the oil level at long intervals, for which purpose a gage cock is provided. The worm shaft is carried on ball bearings and the wheel shaft on Timken bearings. The worm and worm shaft are of carburized nickel steel, heat treated after machining, while the worm wheel is of chill-cast bronze with hobbed teeth. The units are supplied for either top or bottom drive, with shaft extension to either right or left, or in both directions. The lower ratios can be used as speed increasing gears up to a maximum speed of 2000 revolutions per minute.



TECHNICIANS HELP REPAIR BATTLESHIPS

▲ Fifty-eight General Electric technicians who were rushed to Hawaii to help repair the Battleships California and West Virginia will receive Navy "E" pins in recognition of their efficiency, Rear Admiral William R. Furlong, commandant of the Pearl Harbor Navy Yard, has informed the company.

The men, gathered from all parts of the country and dispatched to the scene by plane, train and boat, repaired propulsion equipment of the two big vessels. These were damaged so severely in the Japanese attack, the Navy has disclosed, that they settled to the bottom with their decks awash.

Charles Edwin Wilson, veteran engineer who was in charge of the G-E men, was congratulated by Rear Admiral Furlong as follows:

"In recognition of the valuable services performed by you and the other 57 men of the General Electric Company on two important naval vessels in Pearl Harbor, the Commandant of the Navy Yard presents to you and through you presents to each of the other men of this group a Navy 'E' pin.

"This action is taken because the work performed by you on two salvaged ships contributed to the winning of the 'E' pennant by this yard and contributes to the repair of these ships.

"Please accept my thanks and congratulations for your excellent and important work."

For most of the men, the pins amount to a double citation as they are members of General Electric organizations which have previously received the award.

"It was the first time that propulsion equipment of this type and size had ever been repaired under such conditions," said W. M. Denny, head of the General Electric Contract Service Department which handled the undertaking for the Navy's Bureau of Ships.

"The men found the motors covered by thick oil and muck. Some were corroded by salt water. As the apparatus was deep in each ship, everything taken in or out had to be carried by men walking single file on narrow companionways through four decks. Tons of materials were moved this way.

"General Electric was the only private contractor with a crew working in the Yard. The men worked in three shifts, 24 hours a day, seven days a week, in the holds, breathing air pumped from above deck. As a precaution against gas, the Navy at the beginning of the job provided chemically-treated white ribbons which the men wore. Should the ribbons have turned purple, the workers would have had to leave immediately.

"Working space was cramped and

techniques had to be improvised. Motors of this size, some 12 feet in diameter, are normally turned on the side and the laminations stacked and pressed into place. In the battleships, hundreds of thin sheets of metal or laminations had to be stacked and pressed into place, with the stator and rotor in normal operating position, by hydraulic jacks. A combination of these was made to exert 150 tons pressure. Rotors for the motors had to be ground round to a running clearance of approximately one-tenth of an inch.

"Mr. Wilson, one of our most experienced erecting engineers, superintended the work. The Navy, through Captain J. S. Evans, provided all possible priorities for expediting men and material and the apparatus was repaired in record time."

Now 60 years old, Mr. Wilson's career has included electrification of the Trans-Andean Railway, also the Paulista Railway in Brazil, and projects in Mexico, Venezuela, Switzerland, Norway and Russia. He was in charge of General Electric work in Russia when the Dnieperstroy power plant, then largest in the world, as well as several other large projects were completed by the company in that country.

When Commander H. G. Rickover of the Bureau of Ships asked G-E to repair the propulsion equipment, Mr. Wilson was directing installation of two 35,000-kilowatt generators at the Cherokee Dam for the Tennessee Valley Authority. T. V. A. officials cheerfully released him and he flew to Pearl Harbor. Though of the same name and initials, he is no relation of the former General Electric president who is now vice chairman of the War Production Board.

To work under Mr. Wilson, 57 technicians, skilled armature winders, motor experts and supervisors were summoned by telephone from all parts of the country by N. L. Rea and S. W. Emans of the Contract Service Department and dispatched, some by plane, to Hawaii. The largest single group, 20 men from Schenectady, sped west in a special Pullman car. Five men were obtained from the Bureau of Power and Light in Los Angeles.

In charge of the three shifts at first were: Max A. Hinrichs, who flew from San Francisco to serve as Mr. Wilson's assistant; Jessie D. Gardner, whose past experience included con-

A self-powered magnetic scrap picker, designed and constructed by The Timken Roller Bearing Company from odds and ends, was placed in operation recently and is doing the work of six men gathering up scrap in the company's railroad yards. In 2 hours time, it does the work that three 2-man crews formerly did in 24 hours.

Mounted on an ingot buggy, it is powered by a Hercules, Ford V-8 diesel replacement engine that drives a 230 volt d-c generator. The generator supplies power for the magnet and the electric motor drive.

The magnet is 39 in. in diameter and can lift 900 pounds of heavy scrap or 300 pounds of turnings per load. The box on the front of the picker holds about 1200 pounds of scrap. The boom has a 12-foot swing.

F. E. Moore, president, Mathews Conveyer Company, speaking upon the occasion of the award of the Army-Navy "E" flag to this company on January 12, 1943. Army-Navy "E" pins were presented to all of the employees the same day. The entire program was under the direction of W. L. Dean, secretary and treasurer of the company.

struction of the power plant at Stalingrad, Russia; and E. E. Carrier, who had installed electrical apparatus in Cuba, Mexico, Chile, Panama and Manila and the street railway system in Batavia, Java.

Mr. Hinrichs later became ill and his place was taken by Robert Haake who was rushed to Pearl Harbor from Boulder Dam where he had been working on the installation of an 82,-000-kilowatt generator.

At one point, a problem in replacement of material required the direction of Howard Maxwell, managing engineer of the G-E Induction Motor Department at Schenectady. He left Schenectady on a Sunday afternoon, next day arrived in San Francisco, where the Clipper had been held four hours for him, and reached Honolulu on Tuesday.

ARMY-NAVY "E" TO BEARING COMPANY

▲ Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey, has been awarded the Army-Navy "E" for exceptional achievement in the production of war equipment. The ceremony was broadcast on station WOR, Friday, January 22, from 3:45 to 4:15 p. m. Men and women workers of the plant accepted the award in the name of the hundreds of Hyatt boys and their buddies in service. They said, "To us this award means more than Government recognition of a job being well done. We see it as a compelling challenge to extend our efforts even more . . . to accelerate our current unprecedented output of vital precision bearings for war equipment."

KAISER COKE PLANT IN OPERATION

▲ Completion of a portion of the first metallurgical coke plant on the west coast was announced recently by Koppers Company, Engineering and Construction Division. The plant is made up of two batteries totaling 90 Koppers-Becker Coke Ovens of the Koppers-Becker coke ovens of the latest design and includes equipment for recovery of all usual by-products. Built in the San Bernardino Valley for the Henry J. Kaiser Company, Inc., the ovens will furnish more than 900 tons of coke daily for the blast furnace of a steel mill on the west coast.

Construction began on a site formerly occupied by a pig farm and a grove of walnut trees and surrounded by nut, fruit and eucalyptus trees. Coal was charged on the first battery of ovens last December. Wherever possible concrete and wood were used in the construction, with a consequent saving of steel. Design, purchasing, foundations and erection were carried out by the Engineering and Construction Division of Koppers Company.

The by-product equipment provides for recovery of tar, ammonium sulfate, benzol, toluol, xylol, solvent naphtha and phenols, including the extraction of phenol from waste liquors by the Koppers dephenolization process. This chemical equipment was erected outside wherever possible. The arrangement is such that it may be readily expanded with additional units if desired.

NEW METHOD OF BEARING PRODUCTION

▲ Savings of more than 99 per cent in the tin content of bearing babbitt, and the possibility of completely eliminating costly anchoring methods were two of the outstanding advantages recently disclosed in tests being made at The Cooper-Bessemer Corporation of Mt. Vernon, Ohio, and Grove City, Pennsylvania.

According to research and development engineers of this pioneer diesel and gas engine manufacturer, a comparatively new metal cleaning method known as the "Kolene" process was credited largely for their success in being able to use and satisfactorily anchor lead-base bearing babbitt.

The "Kolene" process is unique in that it provides an exceptionally firm and uniform bond between lead-base babbitt alloy and the Meehanite metal from which Cooper-Bessemer bearing shells are cast.

Using an engine-driven compressor as an example, T. E. Eagan, chief metallurgist, revealed how the huge engine's bearing shells and crosshead shoes were cleansed of surface impurities by means of immersion in salt bath solutions.

The bearing shells are first dipped into a hot molten salt bath to remove the carbon (graphite) particles common in cast iron. By cleaning out these particles in the metal, a considerable amount of anchoring surface

George W. Putnam, acting district manager, Central Alloy District, Republic Steel Corporation; Lt. Commander P. S. Sessions and Brigadier General Trelawney Marchant (left to right) display the Army-Navy "E" flag which was awarded to the Canton and Massillon Works of Republic Steel Corporation on Tuesday, January 19. The Gadsden and Birmingham plants of Republic also received "E's" on January 27.

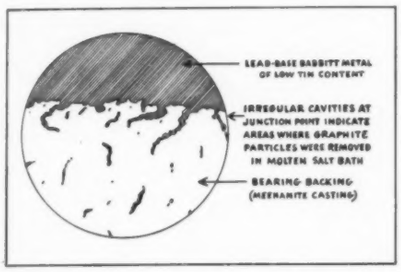
is added for bonding the babbitt as indicated in the accompanying illustration.

After rinsing, the backings are placed in another salt bath to reduce surface oxidation resulting from the first bath.

The backings are again rinsed and suspended for a few seconds in cold hydrochloric acid before they are dipped in a flux and placed in a low tin-content alloy which forms a uniform coating on the bearing surface.

The bearing backings, so coated, are placed in proper jigs, and babbitt is poured against them, which readily forms the tight bond necessary to stand the pressure and stresses of big-engine operation.

The bonding is so uniform and firm that it has been possible to reduce the bearing thickness to a small fraction of the bearing thickness formerly required. This thin bearing alloy has stood up remarkably well under the most severe testing conditions.


LEAD-BASE BABBITT METAL OF LOW TIN CONTENT
IRREGULAR CAVITIES AT JUNCTION POINT INDICATE AREAS WHERE GRAPHITE PARTICLES WERE REMOVED IN MOLTEN SALT BATH
BEARING BACKING (MEEHANITE CASTING)

It is also pointed out how this new development may eliminate machine grooving of the bearing backings — a time-consuming operation used to anchor the bearing metal to the castings. It also opens up new possibilities for cutting weight and saving Meehanite metal by reducing wall thickness of the castings.

The installation for handling the "Kolene" process at Cooper-Bessemer's Mt. Vernon works is said to be one of the largest of its kind in the country and is indicative of the constructive efforts being made at this war plant to meet today's critical material shortages despite accelerated production demands.

EXPECT SHORTAGE OF CUTTING GASES

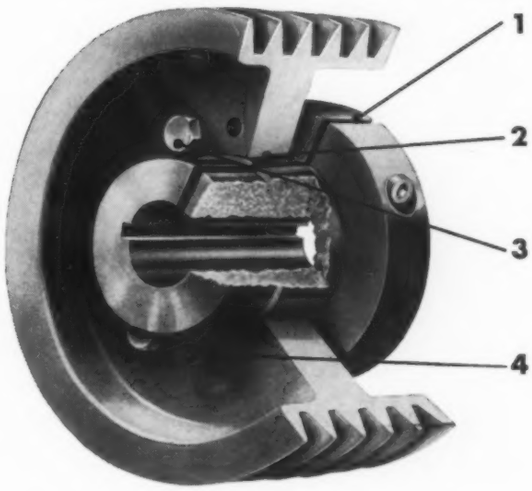
▲ Shortages of both oxygen and calcium carbide are anticipated during the early part of this year, members of the Oxygen and Acetylene Industry Advisory Committee were told at a meeting in Washington.

WORTHINGTON

QD QUICK DETACHABLE SHEAVES

Easy to get on
Easy to get off

...YET ALWAYS TIGHT ON THE SHAFT



1. **SPLIT HUB** for easy mounting or removal from the shaft.
2. **TAPERED FIT** between split hub and rim for easy mounting or removal of rim from hub.
3. **PULL-UP BOLTS** which pull the rim onto tapered split hub for tapered friction drive assembly and positive press fit on the shaft.
4. **TAPPED HOLES IN RIM** for using pull-up bolts as jack screws to free the tapered friction fit when detaching rim.

Ask our nearest District Office for a demonstration of the Time-Saving, Labor-Saving and Material-Saving advantages of the QD Sheave.

MV3-2

WORTHINGTON
COMPLETE DRIVES — MULTI-V-DRIVES — SHEAVES OR BELTS ONLY
WORTHINGTON PUMP & MACHINERY CORPORATION • GENERAL OFFICES: HARRISON, N. J.

A recent survey of oxygen requirements compared with oxygen production indicate a serious shortage during the first half of 1943, government representatives told the members. This shortage may be aggravated and prolonged, depending upon the completion of new plants under construction. Members were asked to advise the Chemicals Division of places where conservation measures can be applied and where consumption can be reduced with the least hindrance to the war effort.

A discussion of calcium carbide, the raw material used for the production of acetylene, indicated that requirements will be considerably greater than production for several months, and possibly longer if current plant expansion and construction is further delayed. Stocks will be reduced to a bare minimum shortly, making necessary drastic cuts in allocations and probably curtailment of small orders.

These commodities are vital to the production of synthetic rubber, many war chemicals, ships, steel, airplanes, tanks, and other implements of war.

A sub-committee was appointed to study the cylinder turn-over so that some plan may be adopted for equitable distribution to the industry of new cylinders expected to be made available some time in the spring. All gas producing companies requiring cylinders during 1943 were asked to advise the War Production Board of their requirements.

Cross-hauling of compressed gases and of calcium carbide was discussed, and a complete study is to be made of ways to eliminate unnecessary hauling.

The committee members were told that no more trucks are being made for industry, and that the comparatively small pool probably would be exhausted before long. The industry should make known the number and types of trucks and trailers they will need.

A representative of the War Manpower Commission told the members that the shortage of manpower will become increasingly serious and the industry should train men to replace those liable to the draft. Also, requests for deferment of key men should be made before reclassification. The Commission has agreed to cooperate on specific problems of this nature, he said.

The Farrel Type TT Roll Grinder grinds straight, convex or concave rolls to exact symmetry and accuracy and with the highest finish attainable by grinding.

The patented crowning and concaving mechanism built into the machine produces a mathematically accurate curve of correct shape for a crowned or concaved roll, exactly symmetrical on both halves of the roll. The mechanism is the adjustable, single eccentric type, readily accessible and quickly set. Only a minimum of skill is required in setting up and operating the machine.

Many other important features of Farrel Type TT Roll Grinders contribute to superior performance, better finish and high output. They are described in detail in our new Bulletin No. 113, which we shall be glad to send without obligation on request.

FARREL
FARREL-BIRMINGHAM COMPANY, Inc.
ANSONIA, CONN.
New York • Buffalo • Pittsburgh • Akron • Los Angeles

RECEIVES AWARD FOR MERITOUS SERVICE

▲ Philco Corporation has been awarded the Army-Navy "E" with a white star for continued "meritorious services on the production front," according to word received recently from Robert P. Patterson, Under Secretary of War.

Converted 100 per cent to war work, Philco is turning out electronic equipment for planes, ships, and tanks, shells, fuzes and industrial storage batteries for the Government.

War production is running at a considerably higher rate than ever before, and is expected to increase further in the next few months.

The original "E" Award presentation to Philco Corporation, one of the first in the country, was made on August 14, 1942 by Brigadier General A. A. Farmer, Commanding Officer, Philadelphia Signal Depot.

In writing to inform Philco of the new award, the Hon. Robert P. Patterson said:

"I am pleased to inform you that

easy

Easy is a good word to describe the way Heppenstall Automatic Safe-T-Tongs do a handling job. This is the way they operate: First you loser them on the work this way... A little slack and the tongs unlock for lifting ... The tongs grip as they come up... The carry is safe, sure and fast... and when the burden is deposited the tongs lock open automatically... ready for the next job.

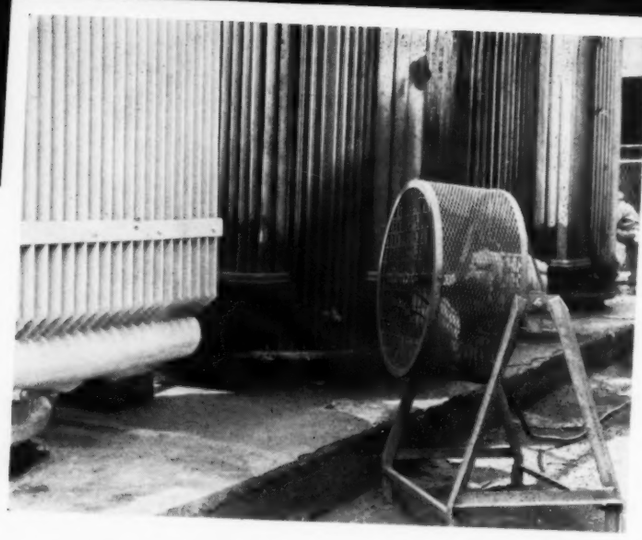
Many hundreds of these tongs are now used in all parts of the country to add speed and safety to materials handling. Each set is designed for the specific job to be done whether it's lifting sugar sacks... or gun barrels... Why not write for this descriptive book... It may give you ideas. Address Dept. T11 Heppenstall Company, Pittsburgh.

Heppenstall Automatic Safe-T-Tongs

Let Truflo Fans . . .

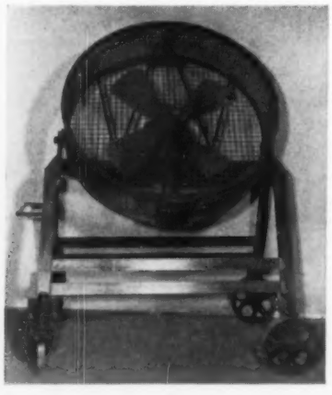
Help keep your workmen on their toes

Portable Fan No. TF-100, recognized as standard in many of the country's largest mills. Sizes from 12 in. to 36 in. in diameter.



Portable Fan No. TF-300 in operation, cooling large transformers in strip mill.

Crane Cab Fan, for cooling crane cab interiors and other confined areas. Available in 12 in. and 18 in. sizes, adjustable both horizontally and vertically.



Portable Fan No. TF-300W. Angle iron support adjusts for vertical or horizontal discharge through almost 360°.

It's more important now than ever before to keep your workmen comfortable. For comfortable workmen are more efficient, produce more work in a given time.

Truflo Fans can help you keep your workmen on their toes. All Truflo Fans are designed and built correctly for efficient, economical operation — they move more air per dollar. Write for free literature on any of the following styles:

Portable Cooling Fans • Crane Cab Fans
Wall Fans • Exhaust Fans • Blowers
Roof Ventilating Fans • Pent House Fans

TRUFLO FAN COMPANY

554 MAIN STREET HARMONY, PA.

you have won for the second time the Army-Navy Production Award for meritorious services on the production front.

"You have continued to maintain the high standard that you set for yourselves and which won you distinction more than six months ago. You may well be proud of your achievement.

"The White Star, which the renewal adds to your Army-Navy Production Award flag, is the symbol of appreciation from our Armed Forces for your continued and determined effort and patriotism."

HOPPER HANDLES BULK MATERIAL

▲ To make possible a standard method of handling hopper-contained bulk materials in a wide variety of production operations, Towmotor Company, Cleveland, has developed a hopper attachment which demonstrates that flexibility essential to efficient performance on individual, specialized jobs can be attained with standard lift truck models.

Designed for use with standard fork equipment, the hopper is available in various sizes, that illustrated having a capacity of 17½ cubic feet. To provide a firm carrying position and permit rapid tilting in dumping hopper loads, the attachment is carried directly on the fork support bar of the lift truck by means of a hook arrangement which is an integral part of the hopper. As shown in the accompanying photograph picturing forks in a lowered position, ample clearance beneath hopper allows handling without removal of standard forks. Hopper gate is opened for discharge by pulling down a hand lever positioned within easy reach of operator, while quick, complete emptying is assured by the slanting hopper bottom. The gate is closed by gravity and is secured by an automatic-catch latch.

Especially suitable for efficient, economical handling of small parts and bulk materials chuted from storage bins or discharged from production machines, the hoppers afford an extremely practical means of collecting materials at production or processing points and quickly transporting them to other locations. As independent units they can be placed for filling while the Towmotor is busy on other jobs, then picked up and hurried to the next destination.

Literature Available

▲ For machine tools, textile machinery, pumps, fans and similar machines, a new Size 2 Class 11-200 Linestarter requiring less than half the mounting space of former units without sacrifice of wiring space is announced by Westinghouse Electric and Manufacturing Company.

This compact Linestarter designed for group mountings, built-in applications or remote mountings has a new clapper-type armature with knife-edge bearings. It utilizes double-break silver to silver contacts, thus eliminating shunts and reducing maintenance. Overload relays are reset either by hand or automatically. On applications requiring sequence or auxiliary interlocking, provision is

for
ATMOS
GAS
from 1,000 to 30,000 c. f. h.
the Kemp Atmos Gas Producer is designed to fit the job including the auxiliaries most efficient in producing the desired results for the specific material being treated. Kemp experience will be helpful in meeting your bright annealing problem. It is yours on request. Address The C. M. Kemp Mfg. Co., 405 E. Oliver St., Baltimore, Md.
ARMY E NAVY
The Army-Navy E Flag, awarded "for high achievement in the production of materials of war", proudly flies at the C. M. Kemp Mfg. Co.
KEMP of BALTIMORE

made on the Size 2 Line starter for a total of four normally open or normally closed electrical interlocks.

All parts of the new unit are accessible from the front and all control circuit terminals and interlock terminals are clearly marked for easy installation and repair.

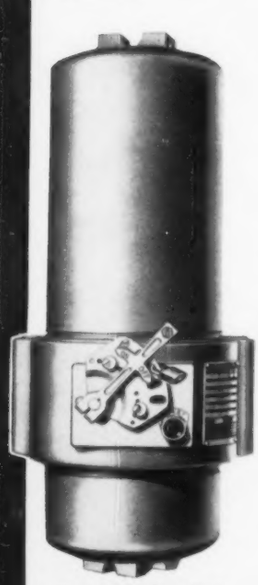
Further information concerning the new Linestarter may be secured from Department 7-N-20, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

▲ The Lubriplate Division of Fiske Brothers Refining Company, 129 Lockwood Street, Newark, New Jersey, has just released for distribution Bulletin No. 1-43, in which is set forth much valuable information relating to the installation, care and lubrication of ball and roller bearings. Operating and maintenance engineers interested in securing best possible operating performance and long life of anti-friction bearings should write for free copy of this important bulletin.

CROUSE-HINDS
CONDULETS
for uninterrupted service

Now, when the demands of the defense program call for greater and still greater production, shutdowns caused by either equipment failure or sabotage can be disastrous. This is no time to take chances. In remodeling or expansion plans, specify Crouse-Hinds **CONDULETS**. Then you can be sure that these sturdy conduit fittings and enclosures will give your electrical system maximum protection against tampering and accidental electrical failures.

CONDULETS—The standard of quality in the field of conduit fittings.

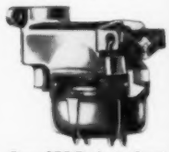


Type EPC Explosion-Proof Combination Line Starter Conduilet — Air Break
Handle Padlocked

Type GUSC Explosion-Proof Line Starter Conduilet
Padlocked in "off" position

Type WMK Weather Resistant Safety Switch Conduilet
Cover and handle may be padlocked together

Type FS Vaportight Switch Conduilet, Key Operated



Type OFC Explosion-Proof Push Button Station Conduilets
With padlock

Type ZT Safety Switch Conduilet
Double padlock protection

A Nationwide Distribution Through Electrical Wholesalers

CROUSE-HINDS COMPANY
SYRACUSE, N. Y., U. S. A.

Sales Offices: Birmingham — Boston — Chicago — Cincinnati — Cleveland — Dallas — Detroit — Houston — Kansas City — Los Angeles — Milwaukee — Minneapolis — New York — Philadelphia — Pittsburgh — San Francisco — Seattle — St. Louis — Washington
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CROUSE-HINDS COMPANY OF CANADA, LTD., *Main Office and Plant:* TORONTO, ONT.

▲ Pennsylvania Transformer Company, Pittsburgh, Pennsylvania, announces the availability of their new catalogue on Distribution Transformers. This 32 page booklet features the distribution transformers that follows the standards set up by the E. E. I.-Nema. Much useful information such as core and coil construction, tank and bushing construction, high and low voltage lead assembly, mountings and hangers, standard accessories and outline drawings are fully covered in this catalogue.

▲ "Selas Superheat Burners, high-speed concentrated heat sources fueled with gas and air only" — A new 8-page 2-color catalog (8½ x 11), 28 illustrations, introducing radical equipment for flame-hardening, flame-annealing, mechanized-brazing, preheating and other localized open heat treatments. Jobs being done, metallurgical advantages, and application and control technique are all discussed — as well as constructional details and operating principles. Full capacity and selection data included. Diagrams describe special modifications of burners for particular war production jobs; photographs show various automatic "machine-tools-for-heat-treatment" designed around the new air-gas combustion technique. Applications to the production of: gears, valve and mechanism parts, caterpillar treads, steel barrel and tank heads, blades, saws, camshafts, sprockets, cartridge cases, gun parts, armor piercing shot, and spun vessels, are mentioned. Selas Catalog No. 251-B. Copies on request to the Selas Company, Philadelphia, Pa.

▲ A new illustrated manual of globe and check valves available through distributors has just been published, and is now being offered users of high pressure valves. It is known as Watson-Stillman Bulletin A-4.

Printed in two colors, this 36-page reference book describes and pictures each unit in the manufacturer's line of bronze, forged steel and cast steel valves, and it includes several types never before announced.

To make the bulletin more readily useful, it is divided into six sections, each of which can be immediately located by means of an identifying tab. The headings include bronze globe valves, forged steel globe valves, balanced stop valves, bronze check valves, forged steel check valves and cast steel check valves.

On the same page with each valve

illustrated, readers will find the pressure ratings for the unit shown along with its dimensions and prices in uniformly-arranged tables. In every case a sectional view is provided in addition to the outside picture, and in this way the flow is clearly indicated. Specifications and engineering information round out a complete presentation.

This book is issued by the distributor products division of Watson-Stillman Company, Roselle, New Jersey. The manufacturer is requesting those asking for copies of Bulletin A-4 to use company letterheads.

▲ Hagan rotary forging furnaces are described and illustrated in a new bulletin just issued by the manufacturer, George J. Hagan Company, Pittsburgh, Pennsylvania. The bulletin gives detailed production facts on various Hagan installations.

Hagan furnaces deliver a continuous flow of billets, each heated uniformly from all sides, to pre-specified temperature. Every billet forges the same, cutting rejections to a minimum, states the manufacturer. Die life is increased because each forging is delivered heated to the desired forging temperature.

Other features include accurate heating control resulting in lower furnace temperatures with shorter heating time. Scale is held to the minimum and cold or burned steel is eliminated. The Hagan Rotary Furnace's patented circular hearth construction assures controlled, high speed forging billet output in the minimum floor space. Labor, fuel and maintenance costs are extremely low.

Copies of this new bulletin are available by writing this publication, or direct to Geaorge J. Hagan Company, 2400 E. Carson Street, Pittsburgh, Pennsylvania.

▲ What is manganese steel? What are its constituents? Where does it fit into the war picture? These are only a few of the many questions on this vital metal asked and answered in a new 48 page catalog just issued by the American Manganese Steel Division of The American Brake Shoe and Foundry Company, Chicago Heights, Illinois.

Steel, so essential for the achievements of peace, takes on an even greater significance in time of war. Steel becomes power, for our ultimate defeat of the Axis depends upon ships, planes, guns, tanks and scores of other items fabricated from it. How the use of manganese steel in "tonnage" steel-production helps to offset the destructive effects on mill equipment of impact and abrasion is fully treated. Interestingly presented and profusely illustrated, the catalog has an important message for all companies concerned with the production of steel.

Divided into sections covering the use of "the toughest steel known" in the blast furnace department, the coke plant, the rolling mill and foundry, the booklet also offers a proved method for successfully reclaiming spindles, crabs and coupling boxes by employing Amsco V-Mang build-up welding rod followed by the application of Amsco Hardface welding rod.

Amsco's 400,000 volt X-ray machine, one of the largest used in commercial foundries, is described in this book as one unit of the Brake Shoe's research and inspection facilities. Copies are available upon request. Ask for Amsco Bulletin 1142-SM.

BETTER PRODUCT CONTROL is possible with Hays Draft or Pressure Recorders which are a positive guide to balanced draft conditions in soaking pits, open hearths, slab mills, annealing and other furnaces. They eliminate guesswork, save man power and reduce rejects to the minimum. They are a real help in the all-out effort for bigger and better steel production.

The ten-inch, 24 hour charts give a permanent record of day in and day out performance of every furnace. Two draft values, two pressure values, two differential values or any combination of two of these three values may be recorded. Or temperature may be included if desired and mercury switches may be provided to operate an alarm or a power unit to open and close a damper, etc.

Any way you look at it, the Hays Series OT Draft Recorder is a Guard over furnace operation and merits your investigation. ***Write for Bulletin 39-232.***

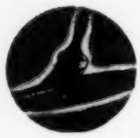
The HAYS CORPORATION
SINCE 1901
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A

How to Get Extra Life and Efficiency From Electrical Wires and Cables

1
STORE CABLES IN A COOL PLACE—High temperatures tend to break down rubber. Stored in a cool (not cold), uniform temperature, cable insulation is kept in the best condition for the longest possible life. Always avoid extreme temperatures.

2
KEEP REELS AND COILS OFF GROUND — Continued moisture rots wooden reel heads and fibrous cable coverings. Round reels are easier to handle and well-preserved cable coverings give longer life in service.

3
PROTECT CABLES FROM WEATHER — Sunshine, light, rain, snow and freezing can hasten deterioration of rubber sheaths and fibrous coverings. Keep cables under cover. Otherwise, be sure to keep lapping on reels.



9
SPLICES WILL LAST LONGER when protected by a coating of weatherproof paint.

10
PROTECT THE JOINTS OF CABLES IN MANHOLES from fire by proper fireproofing.

11
UNDERGROUND INSTALLATIONS (without ducts) — keep ground saturated with water to lower earth temperature and dissipate heat more readily.

12
TUNNEL INSTALLATIONS — ventilate tunnels with grills where possible or install a blower at one end of the tunnel to force hot air out. Make sure circulation goes all the way through tunnel so hot air does not pile up at one end.

13
[illegible] INSTALLATIONS — when possible circulate cool water through or flood duct lines and keep manholes flooded. But be sure your cables are water-tight.

14
[illegible]EAR HEATING UNITS or hot pipes, move or, wiring or insert baffles between steam [illegible]pes and cables to deflect hot air from the [illegible].

15
[illegible]HOT LOCATIONS — Cut air vents in the [illegible]ing or partition above cables to provide [illegible] circulation by means of natural [illegible]ation or install fans.

16
[illegible]CT CABLES for evidence of mechanical [illegible]amination at conduit edges and for corrosive [illegible] deterioration and abrasion. Eliminate [illegible]e here by retaining cables and apply[illegible] protective paint.

17
VENTILATE POLE RISER CONDUITS and create circulation by making openings near the top or by leaving space between the conduit and pothead. This can improve the efficiency of an entire circuit.

18
SPACE YOUR CABLES as close together as possible on overhead circuits if you need to reduce reactive voltage drop. Leave sufficient space for air circulation to prevent overheating.

19
PROTECT cords from being run over by heavy moving equipment, dragged around sharp corners, twisted to remove kinks.

20
SHIFT cords and cables away from high voltage equipment and sparking motors. Such machines generate ozone which attacks rubber and hastens its deterioration.

21
DON'T run cords and cables over small diameter pulleys or drums. Continued bending and flexing around a short radius breaks the conductors. Use larger diameter pulleys.

22
WIPE cords regularly so they are free from oil, grease and chemicals. Such agents attack rubber.

23
KEEP cords out of light and sunshine as much as possible when in use. Light tends to harden rubber — thus hastening cracks.

24
MOVE cords away from steam lines, furnaces and hot objects. High temperatures damage rubber.

[illegible] insulation will then last longer with the [illegible] conductor load, or more current can be carried in the same cable without shortening its life.

[illegible] of the surrounding air (ambient temperature)

Get this Handy Wall Chart FREE!

Now, when electrical wires and cables are difficult or impossible to replace, it is more important than ever that your electrical maintenance men take good care of your wires and cables to secure maximum life and efficiency. This handy wall chart will show them how to do it.

We will be glad to supply, free, as many reprints of this chart as you require.

THE OKONITE COMPANY
and HAZARD INSULATED WIRE WORKS DIVISION
Executive Offices: Passaic, N. J.
Offices in principal cities

PRINTED IN U.S.A. [illegible] BULLETIN OE—[illegible]

THE OKONITE COMPANY — PASSAIC, NEW JERSEY
OFFICES IN PRINCIPAL CITIES

3219

BUY U. S. WAR BONDS *Every Payday All Okonite Employees* BUY U. S. WAR BONDS

... I do mean "And Engineering"!

It is not enough, we think, to build top quality motors; rugged and smooth-running motors; motors of advanced design with unique protective features and low-maintenance advantages. This we do.

But, our job is not done until we have pooled our motor-building ability and engineering experience with your intimate knowledge of the operating requirements in your plant.

FOR MOTOR-DRIVE IS MORE THAN POWER. Properly applied, motor-drive can do *many things.**

Reliance Application Engineers—production minded men with broad experience in many industries—will welcome an opportunity to help you get the right answers to the question—*"What can we make the motor do besides supply power?"*

Just phone or write the Reliance office nearest you.

***Motor-drive provides within itself a means of:**

Speed Control	Reversing
Braking	Remote Control
Tandem Operation	Controlled Acceleration
Tension Control	Safety

Slow Speeds for inching, threading, inspection

Applying them to boost production and improve quality is APPLICATION ENGINEERING. That's our business.

RELIANCE A-C D-C MOTORS

RELIANCE ELECTRIC & ENGINEERING CO.
1088 Ivanhoe Road, Cleveland, Ohio

BIRMINGHAM • BOSTON • BUFFALO • CHICAGO • CINCINNATI • DETROIT • GREENVILLE, S. C. • HOUSTON, TEX. • LOS ANGELES • MINNEAPOLIS NEW YORK • PHILADELPHIA • PITTSBURGH • PORTLAND, ORE. • ST. LOUIS • SAN FRANCISCO • SYRACUSE, N. Y. • AND OTHER PRINCIPAL CITIES

ROCKBESTOS A.V.C.

Prevents Shutdowns because

If repeated wire-failures in circuits around boilers, steam lines, furnaces, lehrs, soaking pits, kilns, etc., are slowing down your production, it will pay you to investigate Rockbestos A.V.C. — the wire with insulation that stands up in the most severe hot-spot installations.

Why does Rockbestos A.V.C. stand up in such service? Because the permanent asbestos braid and felted asbestos insulation is heatproof and fireproof, and won't bake brittle, burn, rot, swell or flow.

Eliminate down-time caused by continual wire maintenance by installing Rockbestos A.V.C. wire, cable or cord in your plant's hot-spots. Our engineers will gladly make recommendations from a line of 122 permanently insulated constructions.

When inquiring or ordering, give end-use classification and authorized priority preference rating. For full information write nearest branch office, or:

Rockbestos Products Corp., 881 Nicoll St., New Haven, Conn.

Why Rockbestos Permanent Insulation provides dependable wire performance

Rockbestos A.V.C. Power Cable above and similarly insulated Motor Lead Cable (Underwriters' and Nat. Elec. Code, Type AVA) has a maximum operating temperature rating of 110°C. (230°F.) and this permanently insulated construction.

1. A tough, rugged asbestos braid, resistant to heat, flame, moisture, oil, grease and corrosive fumes.
2. Outer felted asbestos wall which serves as a heat-barrier against high ambient temperatures.
3. Lubricated varnished cambric for high dielectric strength and added moisture resistance, protected from heat and flame by two felted asbestos walls.
4. Felted asbestos insulation that withstands conductor-heating overloads and won't burn even when exposed to copper-melting arcs.
5. The conductor is perfectly and permanently centred in helically applied insulation.

One of 122 different wires and cables developed for severe operating conditions.

WON'T bake brittle, bloom, burn or rot
RESISTS moisture, oil, grease and fumes

ROCKBESTOS A.V.C.
The Wire with Permanent Insulation

NEW YORK, BUFFALO, CLEVELAND, CHICAGO, PITTSBURGH, ST. LOUIS, LOS ANGELES, SAN FRANCISCO, SEATTLE, PORTLAND, ORE.

ITEMS OF INTEREST

C. W. Heppenstall was recently honored at a banquet in observance of his golden anniversary business career. Over a 130 of his friends and associates attended this affair.

Fifty years ago, C. W. Heppenstall quit a job as a day laborer buildings roads in Highland Park, Pittsburgh, and went to work as a $20 a month office boy for Trethewey Manufacturing Company, an organization in which his father, Sam Heppenstall, a native of Rotherham, England, held a small financial interest. Largely through the efforts of father and son, the company, which was virtually bankrupt at the time, gradually prospered and became Heppenstall controlled. The name was changed to Heppenstall Forge and Knife Company in 1904 and finally to Heppenstall Company in 1930.

Since 1893, the company has grown from a little concern occupying half an acre on 47th street in the Lawrenceville section of Pittsburgh to one of the largest organizations in the country specializing in forged steel products. C. W. Heppenstall was elected president in 1923 and chairman of the board in 1939.

James A. Rowan, formerly news and market editor, *Iron Age*, has been appointed special assistant to the director of the steel division, War Production Board. He was educated at Sibly College of Engineering, Cornell University, and has had wide newspaper experience.

Dr. Richard J. Bennett, Jr., has been appointed chief surgeon, Chicago district, Carnegie-Illinois Steel Corporation. He succeeds Dr. Philip H. Kreuscher who is retiring to devote his entire time to his private interests.

Dr. Bennett has been connected with this United States Steel Corporation subsidiary since January 1, 1937 when he was appointed associate chief surgeon. Born in Chester, Pennsylvania, he took his pre-medical training at the University of Pennsylvania and Temple University. Following the completion of his medical course at Temple in 1927 he spent 2½ years as an intern and resident in surgery at the Philadelphia General Hospital. He then went to the Mayo Clinic at Rochester, Minnesota, on a fellowship in surgery, remaining there until 1934. He specialized in surgery at Edmonton, Alberta, Canada, for a period of 3 years prior to coming to Chicago to join the medical staff of Carnegie-Illinois.

Dr. Bennett is a member of the staffs of the Wesley Memorial and Little Company of Mary Hospitals, the American, the Illinois State, and Chicago Medical Associations, and a Fellow of the American College of Surgeons. In 1940 he was granted a certificate of qualification by the American Board of Surgery.

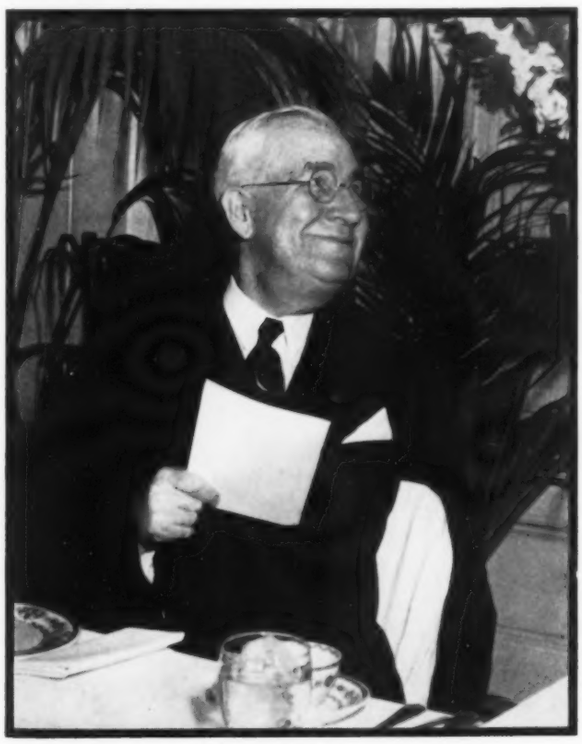
Captain Nelson W. Pickering, USNR, has been ordered to report for active duty in the United States Navy on February 1, and accordingly has resigned as president of Farrel-Birmingham Company, Inc., of Ansonia, Connecticut and Buffalo, New York. Captain Pickering will be attached to the Third Naval District at New York, in charge of operations of district patrol vessels.

Before coming to Farrel-Birmingham Company in 1919, Captain Pickering served for fifteen years in the Navy. After his graduation from the United States Naval Academy in 1908, he was assigned to sea duty, and subsequently was selected for post graduate instruction in ordnance engineering, which included duty at the Naval Gun Factory, Washington, D. C., the proving ground at Indian Head, Maryland, and the Bethlehem Steel Company.

Arthur Hjortsberg, assistant division superintendent, central mills, Gary works, Carnegie-Illinois Steel Corporation, United States Steel Corporation subsidiary, since November 1, 1940 has been appointed division superintendent of these mills succeeding R. F. Campbell, retired. Edwin H. Gott who has been assistant division superintendent of maintenance since October 1, 1941, has been made assistant division superintendent, central mills. Leroy J. Eddy, assistant chief engineer since September 1, 1941, receives the post of assistant division superintendent of maintenance succeeding Mr. Gott. J. Donald Rollins, project engineer since October 1, 1940 has been advanced to the position of assistant chief engineer succeeding Mr. Eddy. George Chacharis, appropriation control and project engineer since April 12, 1942, has been appointed project engineer succeeding Mr. Rollins. George P. Burks, second assistant superintendent of blast furnaces since April 1, 1942, has been made first assistant superintendent of blast furnaces succeeding C. V. Lauer, deceased. Raymond

(*Please turn to page 108*)

C. W. HEPPENSTALL
"... Honored as He Rounds out Fifty Years of Service with Heppenstall." BUD SCOTT PHOTO



New Members

Active

William J. Allsopp
Draftsman
Republic Steel Corporation
Birmingham, Alabama

Herbert N. Andrews
Engineer
Republic Steel Corporation
Warren, Ohio

Malcolm B. Antrim
Tech. Asst. to Elec. Supt.
Technical Assistant to Electrical Superintendent
Lukens Steel Company
Coatesville, Pennsylvania

Roy D. Bane
General Superintendent, Sheet and Tin Depts.
Republic Steel Corporation
Warren, Ohio

Bruce B. Bargman
Assistant Power and Fuel Engineer
Carnegie-Illinois Steel Corporation
Munhall, Pennsylvania

Joseph P. Bendt
Engineer
Algoma Steel Corporation, Limited
Ontario, Canada

Major Carlos Berenhauser, Jr.
Electrical Engineer
National Steel Company of Brazil
Cleveland, Ohio

Wilton E. Boyd
Engineering Designer
Republic Steel Corporation
Warren, Ohio

George S. Cooper
Draftsman
Republic Steel Corporation
Warren, Ohio

George H. Cronin
Chief Draftsman
Wheeling Steel Corporation
Yorkville, Ohio

W. E. Davidson
Engineering Draftsman
Republic Steel Corporation
Warren, Ohio

George L. Dell
Foreman, Lacquer Department
Republic Steel Corporation
Warren, Ohio

L. C. Downey
Principal Engineering Draftsman
Sloss-Sheffield Steel & Iron Company
Birmingham, Alabama

Samuel W. Ellis
Engineering Designer
Republic Steel Corporation
Warren, Ohio

David Evans,
Foreman
No. 2 and 3 Strip Mill
Republic Steel Corporation
Warren, Ohio

William Fahndrich
General Foreman
Sheet and Tin Electrical
Republic Steel Corporation
Warren, Ohio

Clarence D. Foight
Design Engineer
Carnegie-Illinois Steel Corporation
Munhall, Pennsylvania

P. V. Frankenstein
Chief Draftsman
Republic Steel Corporation
Warren, Ohio

R. C. Gintert
Superintendent
Hot Strip Rolling Mill
Republic Steel Corporation
Warren, Ohio

K. W. Harris
Engineer
Republic Steel Corporation
Warren, Ohio

Joseph J. Hiegel
Electrical Draftsman
Republic Steel Corporation
Warren, Ohio

Howard K. Ihrig
Assistant Chief Engineer
Republic Steel Corporation
Warren, Ohio

Henry E. Keil, Jr.
Testing Engineer
Carnegie-Illinois Steel Corporation
Clairton, Pennsylvania

Carl F. Krauss
Engineering Squad Boss
Republic Steel Corporation
Warren, Ohio

Harry Lucas
Foreman
Steam Power Department
Great Lakes Steel Corporation
Ecorse, Michigan

Fred H. Luther
Squad Leader
Engineering Department
Republic Steel Corporation
Warren, Ohio

E. J. McCauley
General Foreman
42 inch Hot Strip Mill
Republic Steel Corporation
Warren, Ohio

John W. McMahon
Superintendent
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Republic Steel Corporation
Warren, Ohio

John E. Marsh
Draftsman
Republic Steel Corporation
Warren, Ohio

H. C. Miller
Chief Engineer
Alan Wood Steel Company
Conshohocken, Pennsylvania

O. W. Morris
Combustion Engineer
American Rolling Mill Company
Ashland, Kentucky

H. P. Munger
Superintendent
Electroplating
Republic Steel Corporation
Warren, Ohio

Charles R. Nims
Draftsman
Republic Steel Corporation
Warren, Ohio

Wilbert H. Phillips
Supervisor
Rolling Department
Carnegie-Illinois Steel Corporation
Braddock, Pennsylvania

W. H. Powell
Structural Engineer
Republic Steel Corporation
Warren, Ohio

E. J. Reardon
Assistant Chief Engineer
American Steel & Wire Company
Cleveland, Ohio

John S. Rinda
Electrical Superintendent
Republic Steel Corporation
Warren, Ohio

Frederick F. Ryder
Heater
96 inch Hot Strip Mill
Jones and Laughlin Steel Corporation
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Maintenance and Power
Bethlehem Steel Company
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Columbia Steel Company
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G. D. Simpson
Assistant General Superintendent
Republic Steel Corporation
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Mechanical Engineer
Alan Wood Steel Company
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George H. Steele
Civil Engineer—Draftsman
Republic Steel Corporation
Warren, Ohio

J. L. Tatman
Assistant Superintendent
Rolling Mills
Edgar Thompson Works
Carnegie-Illinois Steel Corporation
Braddock, Pennsylvania

Charles William Thomas
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Republic Steel Corporation
Warren, Ohio

H. G. Wilbert
Turn Foreman
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Carnegie-Illinois Steel Corporation
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John A. Roebling's Sons Company
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Associate

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Shell Oil Company, Inc.
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W. D. Frey
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Westinghouse Electric and Mfg. Company
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Lewis Foundry and Machine
Division of Blaw-Knox Company
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The Adalet Manufacturing Company
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George M. Harrison
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General Machinery Company
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Julian Kennedy, Inc.
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General Electric Company
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District Engineer, Fire Division
Cardox Corporation
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Sales Representative
Allis-Chalmers Manufacturing Company
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Athas Car and Manufacturing Company
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F. G. Teufel
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Donald R. Wilcox
Service Engineer
Morganite Brush Company
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Yarnall Waring Company
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Switchgear Specialist
General Electric Co.
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C. Allan Harlan
President
Harlan Electric Company
Detroit, Michigan

Carl E. Haugh
Assistant Plant Engineer
United Engineering and Foundry Company
Pittsburgh, Pennsylvania

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Lubrication Engineer
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Chicago, Illinois

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Consulting Metallurgist
Arthur Seligman and Company, Inc.
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Midwestern Manager
Elliott Company
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National Carbon Company, Inc.
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C. P. Sullivan
Construction Engineering Department
General Electric Company
Schenectady, New York

A. A. Straub
Engineer
United Engineering and Foundry Company
Pittsburgh, Pennsylvania

Maj. Arthur V. Wulffen
Chief Industrial Division
Argentine Army Purchasing Commission
New York, New York

•

Junior

Lambert A. Pfeiffer, Jr.
Repairman, Electrical Repair Shop
Great Lakes Steel Corporation
Ecorse, Michigan

Francis M. Hagan
Tester in Metallurgical Laboratory
Follansbee Steel Corporation
Toronto, Ohio

James MacKay
Mechanical and Electrical Detail Man
American Steel and Wire Company
Cleveland, Ohio

James C. Orr
Estimator
Project Engineering Division
Carnegie-Illinois Steel Corporation
Duquesne, Pennsylvania

Homer Roush
Temperature Recorder
New Process Annealing
Wheeling Steel Corporation
Steubenville, Ohio

Richard C. Lightcap
Division Engineer
Carnegie-Illinois Steel Corporation
Youngstown, Ohio

Richard H. White
Power and Fuel Engineer
Carnegie-Illinois Steel Corporation
Ohio Steel Works
Youngstown, Ohio

W. Sundquist, assistant to superintendent of blast furnaces receives the post of second assistant superintendent of blast furnaces succeeding Mr. Burks.

W. W. Lewis, 55, assistant vice president of The American Rolling Mill Company died suddenly on January 23, 1943.

Mr. Lewis was born in Baldwyn, Mississippi, November 28, 1887 and educated at Cumberland University, Lebanon, Tennessee.

He was employed by the Jones and Laughlin Steel Corporation as a first helper in the open hearth department when he accepted a position with Armco as assistant superintendent of the Middletown open hearth department on April 28, 1917.

N·B·M BRONZE AND COPPER CASTINGS

Blast Furnace Copper Castings • Roll Neck Bearings • Housing Nuts • Machinery Castings • Acid Resisting Castings • Phosphorized Copper • Locomotive and Car Journal Bearings • Babbitt Metals

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HEAVY BEVEL LETTERS and FIGURES

These stamps will give an outstanding performance on any type of stamping job. Recommended for stamping armor plate, airplane parts, guns, tank parts and any other steel ordnance product. Will give at least 50% to 100% more service than ordinary stamps because of special alloy steel used. Heads of stamps do not have to be redressed. Available in all sizes 1/32" to 1".

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In times like these the "extra" values of the new

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Increased power.
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Air-controlled frictions.
Anti-friction bearings.
— The proper material for every part properly heat treated.

AMERICAN Locomotive Cranes are built to do a greater volume of work, faster and at much less expense than any other crane you have ever owned. Right now they are practically worth their weight in gold. Keep them in first-class running order with constant care and adjustment. We'll be glad to co-operate to the fullest extent possible.

MAGNET WORK SUPERIORITY

The new streamlined 25, 30, 35 and 40-ton AMERICAN Locomotive Cranes are under such precise control that unusually high scrap tonnages are handled with lifting magnets, even when transferring scrap from cars to relatively small hatchways of ships or barges.

SIXTY YEARS OF SAFETY 1883 1943
The Genuine CROSBY CLIP ☆ ☆ ☆

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Synthite* PX-5

NEW Black Polymerizing Varnish

Not only does SYNTHITE PX-5 Black Baking Varnish cut baking time to a minimum but it also provides better insulation with less coats, thus reducing the number of treating cycles. It possesses excellent flexibility found in the better grades of oxidizing types of varnishes as well as the deep curing properties of synthetic types.

Curing by heat through chemical polymerization, this varnish will dry hard even in the deepest interstices of large coils. Then too, shorter baking will permit flexibility, yet cure the varnish evenly throughout. SYNTHITE PX-5 Black Baking Varnish possesses the essential bonding properties which will hold windings intact under the centrifugal force produced by high speed motors. It is ideally suited for use on the modern types of enamelled magnet wire and Class B insulation.

This material affords maximum resistance to acids and alkalies and can withstand high temperatures. SYNTHITE PX-5 Black Baking Varnish can be applied on all types of electrical units, large or small, and can be baked out by infra-red equipment or the conventional baking oven. In either case, units treated with this varnish will bake out quicker and provide better protection than ordinary insulating varnishes.

- High Dielectric Strength
- Glossy, Tough Film
- Good Adhesion
- Deep Drying
- Waterproof
- Oilproof

The above photograph clearly illustrates the penetrating qualities and thoroughness of curing achieved in using SYNTHITE PX-5 Black Baking Varnish.

Reg. U. S. Pat. Off.

Dolph's

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Insulating Varnish Specialists

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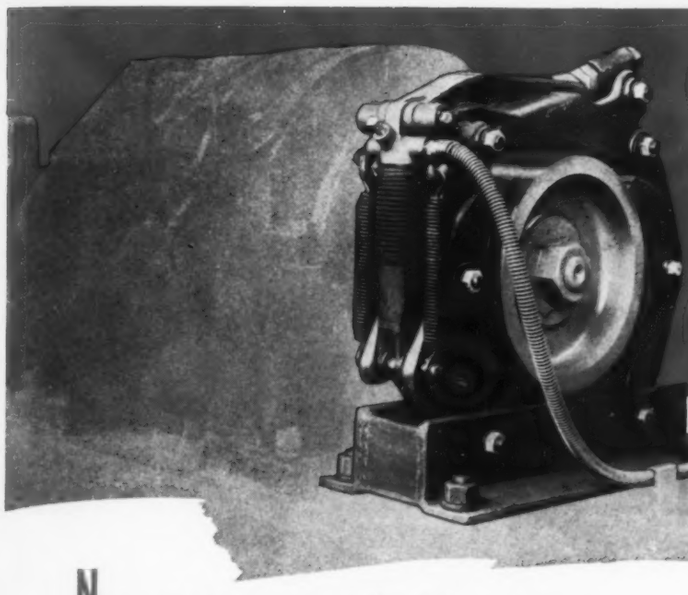


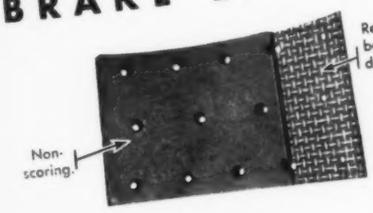
WAGNER
Crane Brake MAINTENANCE

No matter what your crane bridge brake requirements may be, you can look to Wagner for complete hydraulically actuated bridge braking systems for either new cranes or for conversion from mechanical brakes.

Wagner hydraulically actuated bridge braking systems come in two types—type H for inside cranes and type HM for outside cranes where automatic parking attachment is necessary.

A few of the many points of excellence of Wagner hydraulic bridge braking systems are: **1.** Easy one-point adjustment . . . **2.** Exclusive anti-drag device . . . **3.** They have hardened pins, knurled to prevent rotation . . . **4.** They have bushings at points of maximum wear . . . **5.** Grease fittings are provided on all hinge pins . . . **6.** The friction blocks are extra thick, and bolted to the shoes . . . **7.** Wagner provides nation-wide service through twenty-five branches.

BRAKE LINING . .



Preformed in blocks to fit all makes and sizes of crane brakes.

Wagner molded wire-backed blocks have the following advantages: **1.** Non-abrasive—will not score brake wheels . . . **2.** Suitable for use with any type of brake wheel . . . **3.** Preformed to size and molded to wheel diameter . . . **4.** Wire-backed to permit deep seating of lining bolts or rivets . . . **5.** Molded blocks save installation time because they are easily applied . . . **6.** Available from Wagner branch stock . . . **7.** They reduce inventory by eliminating excessive stocks of roll-type lining which is generally purchased in long lengths in order to obtain the best price.

WAGNER HYDRAULIC BRIDGE BRAKING SYSTEM
. . . Complete—Ready to Install on New or Old Cranes

The complete system includes everything necessary—brake assembly, brake wheel, master cylinder, wheel cylinder, tubing, flexible hose, brake fluid, and all fittings.

Brake Wheel furnished with bore as specified.

Brake Assembly—Type H illustrated is for inside cranes. Type HM for outside cranes.

Send Today for Complete Information!

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Wagner Electric Corporation
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BRIDGE BRAKES • TRANSFORMERS • MOTORS

FOR THESE RESULTS USE GATKE moulded fabric SLIPPER BEARINGS

10 times longer service than bronze slippers

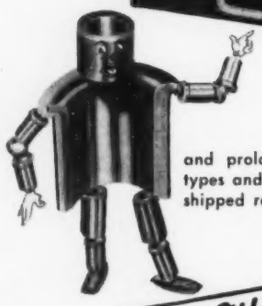
Eliminate scoring and wear to companion parts

Stop destructive vibration and pounding noises

Avoid grease slinging

Save costly machining

Replace critical metals



Only GATKE *makes Self-Alyn* Slippers—the GATKE Invention that eliminates breakage, improves lubrication, and prolongs wear life. Made to fit all types and sizes of Universal Couplings and shipped ready to install without machining.

The incomparable results of GATKE Slippers on *all types and sizes* of Universal Couplings leave no doubt that if you are not using GATKE Slippers, *you are missing plenty.*

Please remember that GATKE Slippers are unique—the product of nearly 10 years pioneer development and specialized experience. Many features are protected by GATKE Patents—the tough fabrics are exclusive GATKE developments, manufactured only in GATKE Textile Plants.

Just write for complete information or send specifications of coupling for recommendation.

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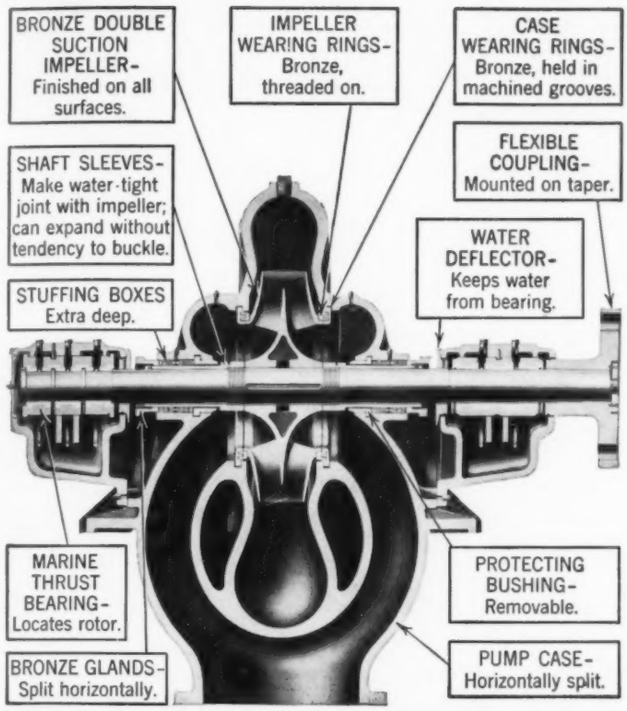
Gatke MOULDED FABRIC Bearings

For Roll Necks, Universal Couplings, Spindle Carriers, Table Rolls, Cranes, Acid Resisting Service, and Other Tough Jobs.

SUSTAINED EFFICIENCY
OF DE LAVAL PUMPS

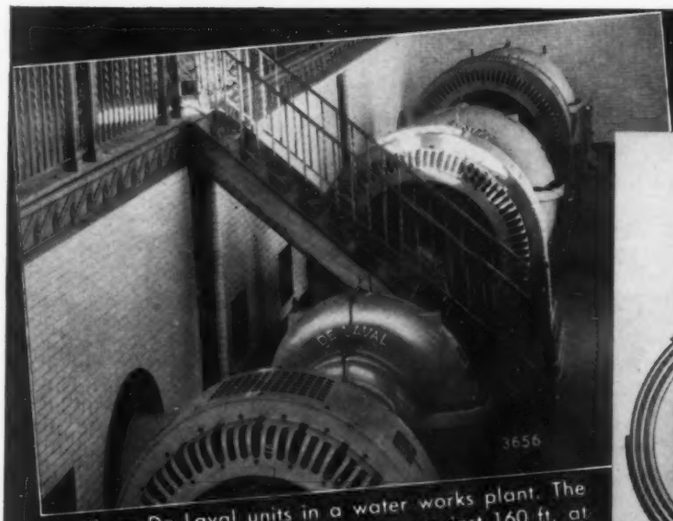

BRONZE DOUBLE SUCTION IMPELLER- Finished on all surfaces.
IMPELLER WEARING RINGS- Bronze, threaded on.
CASE WEARING RINGS- Bronze, held in machined grooves.
SHAFT SLEEVES- Make water-tight joint with impeller; can expand without tendency to buckle.
FLEXIBLE COUPLING- Mounted on taper.
WATER DEFLECTOR- Keeps water from bearing.
STUFFING BOXES Extra deep.
MARINE THRUST BEARING- Locates rotor.
PROTECTING BUSHING- Removable.
BRONZE GLANDS- Split horizontally.
PUMP CASE- Horizontally split.

is due to proper hydraulic design, which avoids cavitation and pitting, and particularly to renewable *LABYRINTH WEARING RINGS*, which protect casing and impeller from erosion and reduce leakage from discharge to suction.

With De Laval *LABYRINTH RINGS* there is only about one-third as much leakage as between plain rings having the same radial clearance, or for the same initial efficiency De Laval pumps can have greater clearances than can pumps with flat rings. Because of the reduced leakage there is less erosion of De Laval rings than of flat rings and efficiency is better sustained. De Laval pumps which have been in continuous service for many years without renewal of parts still equal their original efficiencies, as demonstrated by numerous tests.

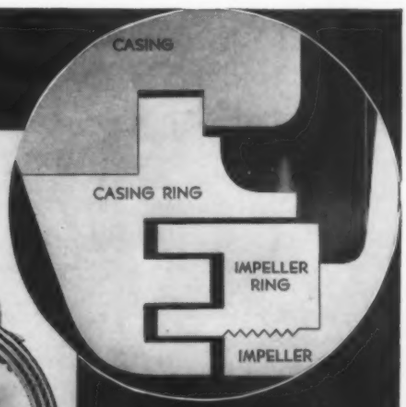
All parts of De Laval pumps are interchangeable on a limit gage basis and renewals ordered by number require no fitting.

State your pumping conditions and ask for Publication P-3222.



Three De Laval units in a water works plant. The largest, rated at 38,000 g.p.m. against 160 ft. at 600 r.p.m., showed on the acceptance test an overall efficiency, including motor, of 88.0 per cent.

Labyrinth case protecting ring.



Section through labyrinth wearing rings.

HYDRAULIC INSTITUTE U.S.A. MEMBER

DE LAVAL *Steam Turbine Co.*
TRENTON, N. J.

MANUFACTURERS OF TURBINES . . . STEAM, HYDRAULIC PUMPS . . . CENTRIFUGAL, PROPELLER, ROTARY DISPLACEMENT, MOTOR-MOUNTED, MIXED-FLOW, CLOGLESS, SELF-PRIMING, CENTRIFUGAL BLOWERS and COMPRESSORS; GEARS . . . WORM, HELICAL and FLEXIBLE COUPLINGS

THE EYES AND EARS OF AN ELECTROLYTIC TIN PLATE LINE

The eyes and ears of an Electrolytic Tin Plate Line are concentrated in the Operator's Central Control Station, which is usually mounted near the entry end of the line. A typical section of a "3C" Control Station is shown.

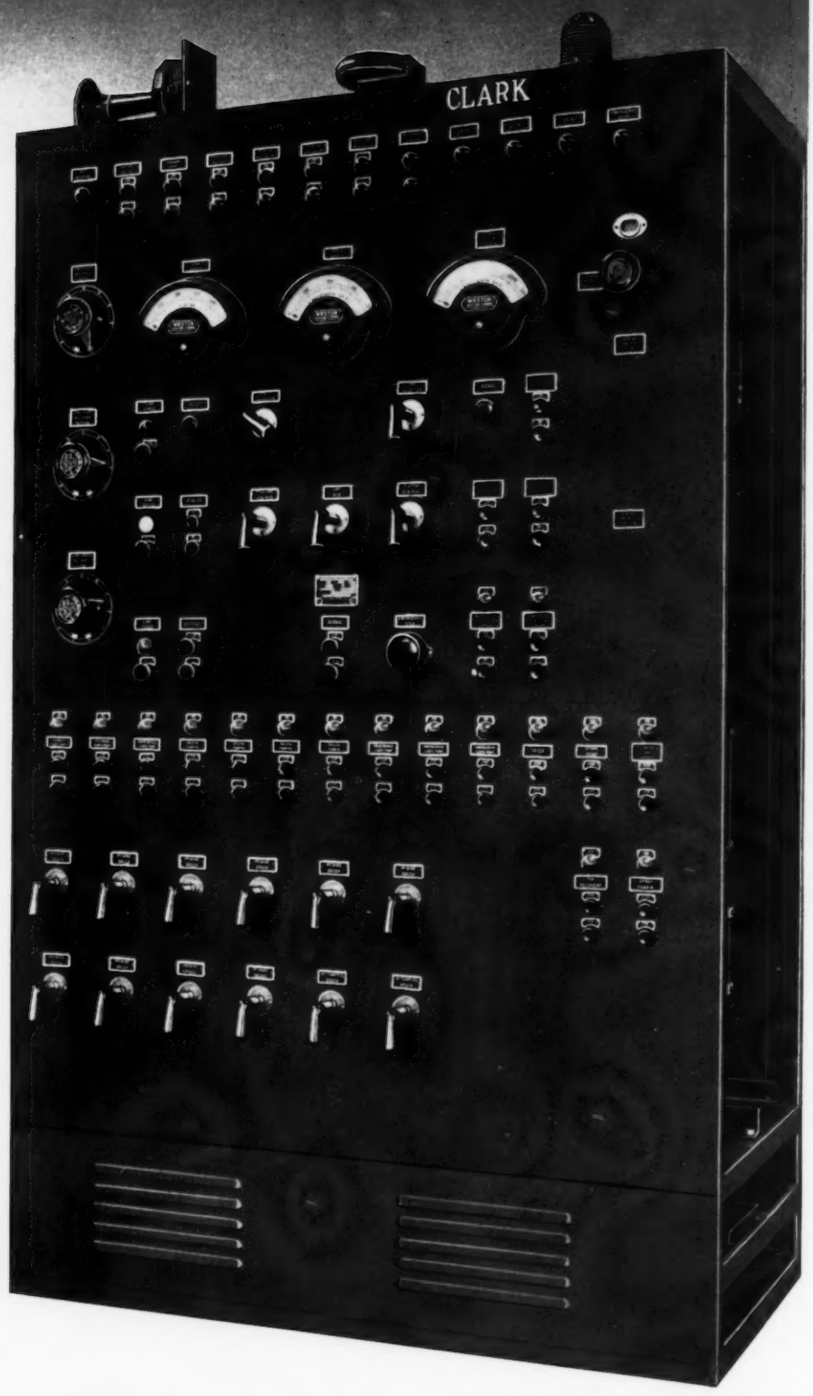
The Siren, Bell and Amber Light, on top of the panel, call attention to overloads or other operational difficulties.

The top row of Pilot Lights indicate whether various functional devices are in proper condition for running the Tinning Line.

Master Switches are operated by Pistol Grips.

Auxiliary motors are started by Push Buttons, with Pilot Lights indicating which motors are running.

This is a compact assembly of many "3C" Electric Control Devices, each functioning to help production of tin plate vitally needed for canning food.



CONTINUE TO ROLL WITH CLARK CONTROL

THE CLARK CONTROLLER CO.

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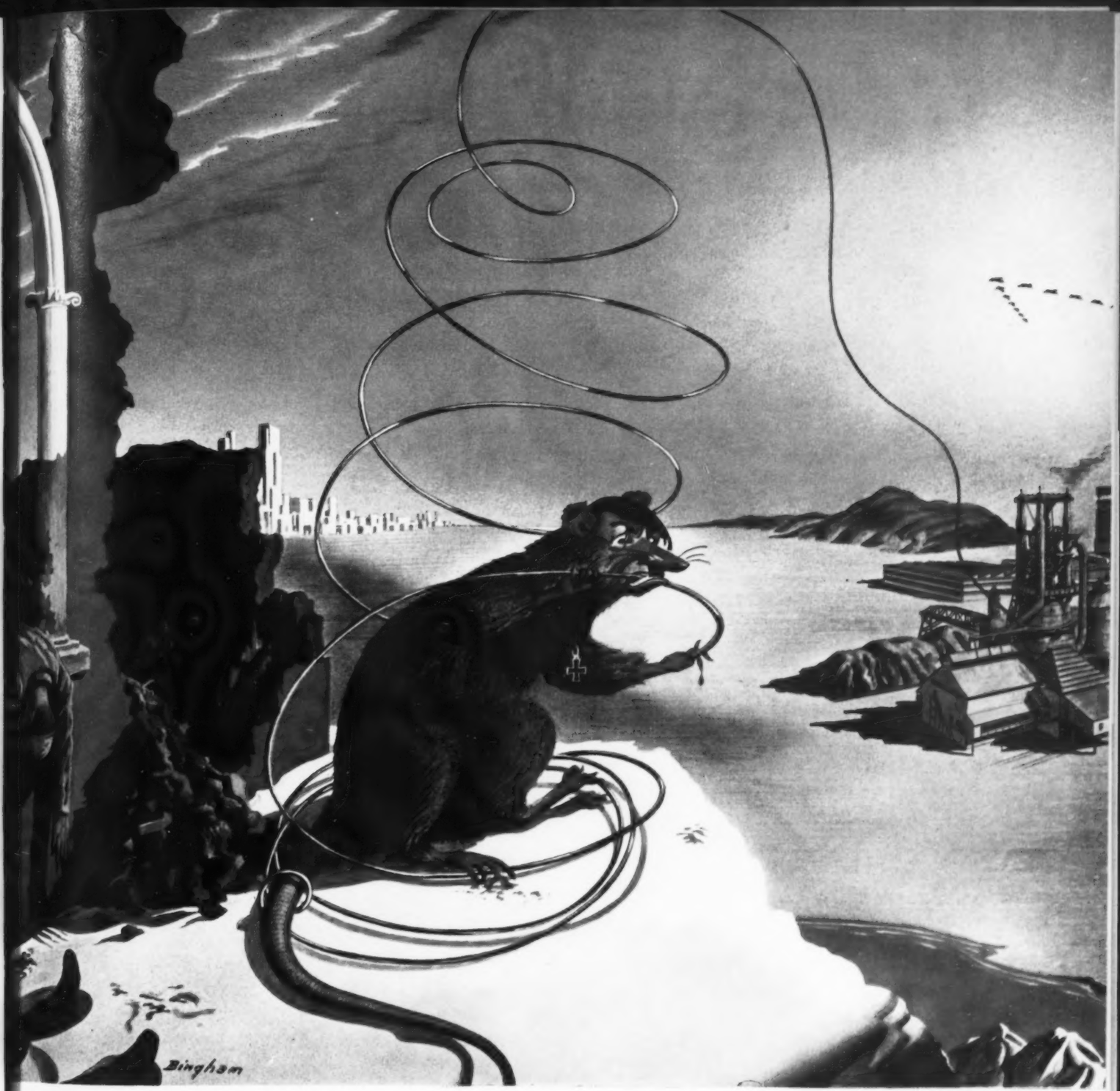

Steel *makes good rat traps*

Funny thing about rat traps, they don't all look like rat traps. Take *coke ovens.* You need *coke* to make iron, *iron* to make steel, *steel* to crush international rats. When the steel industry put into operation currently-built Koppers coke ovens vast enough to produce five million *more* tons of coke annually, that was a major Allied victory. Or take couplings. You can't get enormous steel tonnages if couplings go bad and shut down machinery. That used to happen often, but the steel industry for years has been putting Koppers Fast's Couplings at all vital spots; today, the non-stop records of these couplings are like shots heard round the world. Koppers also serves the Steel industry with coking coal, plants to recover chemicals, D-H-S Bronze and other products.—Koppers Company, Pittsburgh, Pa.

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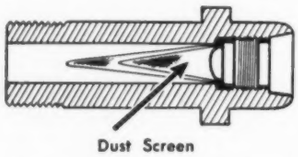
How to Make Welding and Cutting Regulators Last Longer . . . .

GOOD oxy-acetylene welding and cutting depend to a great extent upon smooth, unfluctuating delivery of gases to the blowpipe. This, in turn, depends upon the action of the regulators that reduce the cylinder gas pressure to the desired working pressures. Because of the very nature of the work they perform, oxygen and acetylene regulators must be precision-made. Moving parts must work smoothly and seating surfaces must close tightly. So—while sturdily made—Oxweld, Prest-O-Weld, and Purox regulators should be recognized as *sensitive instruments* and should be treated as such. The suggestions outlined here will help you to make your regulators last longer and work more efficiently.

KEEP DIRT OUT OF REGULATORS

1. ***Crack the cylinder valve*** slightly for an instant and then close it, before connecting a regulator to the cylinder. *This will blow dust and dirt out of the valve and will not only reduce the likelihood of forcing dirt into the regulator, but also will help to avoid damage to the seating surfaces on the regulator inlet connection.*

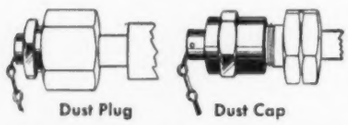
2. ***Dust screens*** are built into the inlet passages of most Oxweld, Prest-O-Weld,



Dust Screen

and Purox oxygen regulators. Do not remove these screens except for periodic cleaning, after which they always should be replaced immediately. *Be careful not to tighten the locking ring too tight as this may shear off the brass screening. Pull it up until it is just "snug".*

3. ***Dust caps*** or plugs are provided on



Dust Plug Dust Cap

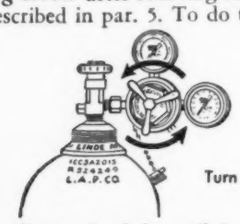
most Oxweld regulators. If your regulators are so equipped, screw them into place whenever the regulator is not attached to a cylinder. Do not remove the chains that attach dust plugs and dust caps to the regulators, as the chains prevent them from being lost.

AVOID EXCESSIVE STRAINS

4. ***When turning gas on*** after attaching a regulator, open the cylinder valve only slightly at first to avoid a sudden rush of high-pressure gas into the regulators and regulator gauges.

5. ***Always release gas pressure*** from regulators when the equipment is not being used. First close the cylinder valves. Second, open the blowpipe valves to release all pressure. Then close the blowpipe valves. *If this is not done, even a very slight leak in the regulator valve seat may permit excessive pressures to build up in the delivery chamber of the regulator and in the hose. This might result in straining the low-pressure gauge or regulator valve, or may even rupture the safety-release disk or the hose.*

6. ***Always release the pressure-adjusting screw*** after relieving the pressure as described in par. 5. To do this, turn the



handle to the left until it turns freely. *This will greatly prolong the life of the diaphragm.*

MAINTENANCE SUGGESTIONS

7. ***Test for leaky valve seats*** at regular intervals. To do this, attach the regulator to a cylinder, release the pressure-adjusting screw, open the cylinder valve, and apply a film of soapy water over the regulator outlet connection. *If the regulator valve seat leaks, the gas that leaks through will blow a bubble and burst the soapy film. Do this periodically, and replace at once seats that leak. This will avoid possible extensive damage and repairs.*

8. ***If a safety-release disk breaks,*** replace it only with the correct part as specified in the instruction book supplied with the regulator. Do not use substitutes. *This is important because disks not especially made to rupture at a pressure commensurate with pre-determined safety requirements may permit pressures to build up, without being released, to a point that could do serious damage.*

9. ***Replace broken gauge crystals at once.*** If this is not done, the needle indicator may be damaged or the dial face may become so dirty that it will not be possible to adjust the regulator accurately to the pressure required for good work.

DUPLICATE INSTRUCTION BOOKS AVAILABLE

It is important that oxy-acetylene apparatus be operated and maintained in accordance with the manufacturers printed instructions. Duplicate copies of the instruction booklets packed with all oxy-acetylene apparatus supplied by Linde can be obtained from any Linde office.

The words "Linde," "Oxweld," "Purox," and "Prest-O-Weld" are trade-marks.

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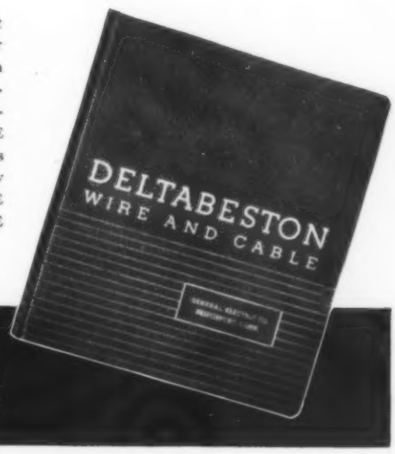
TODAY, the transmission and control of our Nation's power to convert mountains of raw materials into an endless chain of tanks, ships and planes require a rugged and dependable cable.

DELTABESTON Wires and Cables are used on vital war jobs all over the land . . . performing with the utmost dependability under the most severe operating conditions. They last and do the job well . . . where other cables might fail. That's why we're so proud of DELTABESTON. But that's not all—

Designing DELTABESTON Wires and Cables specifically for wartime service has taught us much. Improved methods of manufacture, greater production and better products . . . these are the direct results stimulated by our war effort. In short, we're putting forth our greatest effort so that our fighting forces may have the best. These improvements will be available to all in 194X.

★

Here's the answer where heat is a problem . . . it's yours for the asking. Write to Section Y233-31, Appliance and Merchandise Dept., General Electric Co., Bridgeport, Conn. G-E Deltabeston Wires and Cables are distributed nationally by Graybar Electric Co., G-E Supply Corp. and other G-E Merchandise Distributors.



GENERAL ELECTRIC

Worm gear specifications frequently place Cleveland in the preferred position because Cleveland has:

Experience—more than 30 years devoted to the manufacture of Worm Gearing exclusively.

Knowledge—gained by long-continued Engineering Research into successful applications throughout the heavy industries.

Facilities—a plant built to produce worm gearing by volume precision methods—equipped with machines designed by our own Engineers—expanded to meet increasing demand.

Variety—Seven types cover every basic application in a complete range of sizes and ratios. All are built to Cleveland's uniform standard of excellence.

The Cleveland Worm & Gear Company, 3278 East 80th Street, Cleveland, Ohio.

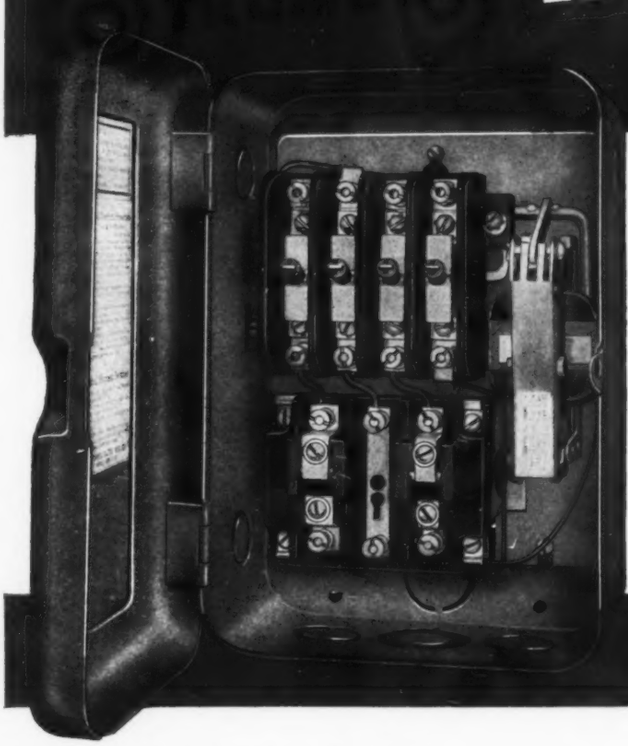
Affiliate: The Farval Corporation, Centralized Systems of Lubrication

In Canada: PEACOCK BROTHERS LIMITED

Write "Cleveland Worm Gear" into *your* specifications and you team up your own demand for continuous operation with Clevelands' proved ability to keep your machines running 24 hours a day. You can bank on Clevelands—for they never will let you down!

CLEVELAND WORM GEAR *Speed Reducers*

magnetics"



1. **STRAIGHT THRU WIRING**—line and load in same relative positions at top and bottom. No confusion.
2. **FRONT MOUNTING OF PARTS**—contacts always visible—never any question about proper contacting, nor danger to motor because of single phasing.
3. **EASE WITH WHICH CONTACTS CAN BE CHANGED** even by unskilled worker—no manipulations by expert mechanic necessary.
4. **NEVER HAS HAD TROUBLE WITH BURN-OUTS ON MOTORS**—one type he used "burned out five motors."
5. **OVERLOAD RELAYS ARE "HONEST"**—always trip on overload as claimed—he has used heaters whose performance has not been in accordance with calibration.

ADDED FEATURES OF "CM"

REMOVABLE INTERIORS: The entire mechanism is mounted on a steel back plate (aluminized finish) and can be removed as a unit by loosening three non-removable screws—for ease in wiring line and load.

SHOCK ABSORBING ARMATURE MAGNET ASSEMBLY: This shock-absorbing, self-aligning mechanism prevents hammer blows as the starter closes—assures long life, eliminates humming and minimizes coil maintenance.

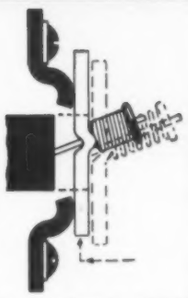
SOLDERLESS LUGS: Sizes 0 and 1 are equipped with special "wire keepers", grooved on the inside to hold wire rigidly in place. Sizes 2 and 3 have Trumbull solderless "Handi-Lugs."

INTERCHANGEABLE RELAY HEATERS: All relay heaters, ½ to 80 amp., are interchangeable. Automatic reset standard, or hand reset on request.

For long life and complete overload protection under severe load conditions specify Trumbull "CM" Magnetic Starters. *Ask for Circular No. 322 and Bulletin No. 404.*

VERTICAL CONTACTS

Pioneered by Trumbull



The Trumbull line of motor starters, both manual and magnetic has long been recognized as a major contribution to the Industry.

One of the best electrical and mechanical devices—Trumbull's vertical, sliding, self-wiping, double-break contact *was introduced by this company in 1927* and has been most effective because it keeps the contact . . .

DUST AND CARBON FREE

at all times. Note the vertical sliding action shown in the accompanying drawing, which wipes the metal *clean* at every operation of closing and opening the circuit. Non-carbonizing glazed porcelain bases also prevent accumulation of both dust and carbon.

AVAILABLE in Sizes 0 ("M"-2), 1 ("CM"-7½), 2 ("CM"-25) and 3 ("CM" - 50).

May be operated by either *remote, local or automatic control.* Also in combination with motor circuit disconnects, contactors and other equipment.

TRUMBULL

MAGNETIC STARTERS

THE TRUMBULL ELECTRIC MANUFACTURING COMPANY · PLAINVILLE, CONN. A GENERAL ELECTRIC ORGANIZATION

OTHER FACTORIES AT NORWOOD (CINN.) O. — SEATTLE — SAN FRANCISCO — LOS ANGELES

TO EXECUTIVES:

NOW YOU CAN HELP

Even More...

New Treasury Ruling Permits Purchases UP TO $100,000, in any Calendar Year, of Series F and G WAR BONDS!

The Treasury's decision to increase the limitations on the F and G Bonds resulted from numerous requests by purchasers who asked the opportunity to put more money into the war program.

This is not a new Bond issue and not a new series of War Bonds. Thousands of individuals, corporations, labor unions, and other organizations have this year already purchased $50,000 of Series F and G Bonds, the old limit. Under the new regulations, however, these Bond holders will be permitted to make additional purchases of $50,000 in the remaining months of the year. The new limitation on holdings of $100,000 in any one calendar year in either Series F or G, or in both series combined, is on the cost price, not on the maturity value.

Series F and G Bonds are intended primarily for larger investors and may be registered in the names of fiduciaries, corporations, labor unions and other groups, as well as in the names of individuals.

The Series F Bond is a 12-year appreciation Bond, issued on a discount basis at 74 percent of maturity value. If held to maturity, 12 years from the date of issue, the Bond draws interest equivalent to 2.53 percent a year; computed on the purchase price, compounded semiannually.

The Series G Bond is a 12-year current income Bond issued at par, and draws interest of 2.5 percent a year, paid semiannually by Treasury check.

Don't delay—your "fighting dollars" are needed *now*. Your bank or post office has full details.

Save With . . .

War Savings Bonds

This space is a contribution to America's All-Out War Program by Iron and Steel Engineer

DEADENDING

Heavy Feeder Cables

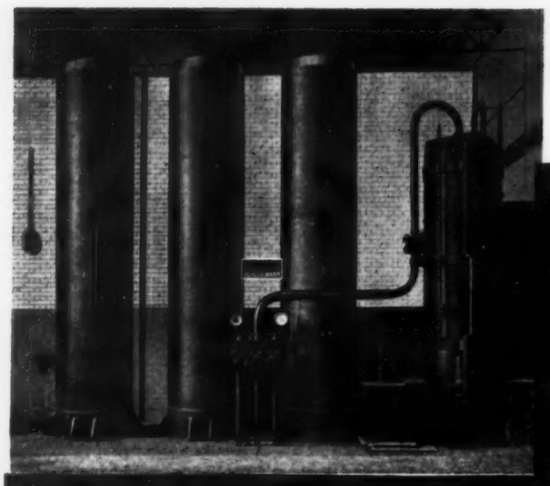
HERE'S a Keystone "hard-to-beat" combination for deadending heavy cables. Long clamping surface provides positive grip on conductor. Note clamp is round and of small diameter to facilitate taping and is free of sharp projections which might pierce tape insulation. In combination with the Keystone Giant Strain Insulator which is porcelain covered for all weather service and backed by over 30 years of unfailing service you have a "hard-to-beat" combination. You can do a better, longer-lasting job with Keystone.

Ask for Catalog

Manufactured by **ELECTRIC SERVICE SUPPLIES COMPANY**

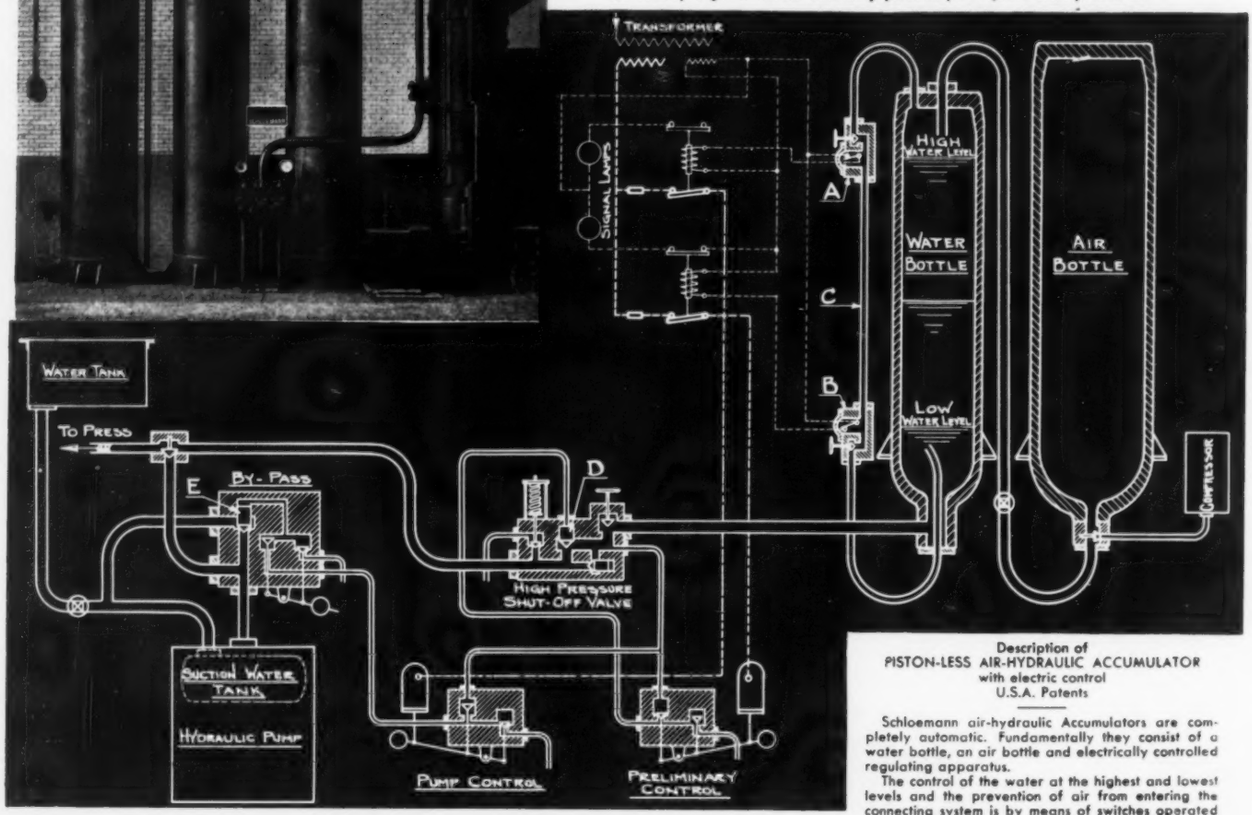
17th and Cambria Streets · Philadelphia · Pennsylvania · Branches in Principal Cities

HEADQUARTERS FOR TRAVELING ELECTRICAL CONTACT AND HEAVY FEEDER SYSTEM MATERIALS



Accumulators furnished in sizes from fifty gallons to twenty-five hundred gallons and for pressures up to forty-five hundred pounds per square inch.

System shown at left has two hundred gallons capacity and is designed for twenty-eight hundred and fifty pounds per square inch pressure.



Description of
PISTON-LESS AIR-HYDRAULIC ACCUMULATOR
with electric control
U.S.A. Patents

Schloemann air-hydraulic Accumulators are completely automatic. Fundamentally they consist of a water bottle, an air bottle and electrically controlled regulating apparatus.

The control of the water at the highest and lowest levels and the prevention of air from entering the connecting system is by means of switches operated by floats contained in chambers of a communicating tube "C." Thus the switch "A" in the upper chamber controls the operation of the hydraulic pump, while that in the lower chamber "B" controls the check valve "D" which shuts off the accumulator at lower water level.

The continuous running pump is controlled by closing the By-Pass check valve "E" by means of the pump control, causing it to idle by opening the same and returning the water to the suction end. Over-pressure is released through safety valves and is indicated by an alarm.

SCHLOEMANN

AIR-HYDRAULIC ACCUMULATORS

HYDRAULIC EXTRUSION PRESSES

HIGH PRESSURE PUMPS

COMPLETE HYDRAULIC SYSTEMS

ENGINEERING CORP. **PITTSBURGH, PA.**
Rolling Mill Machinery Hydraulic Presses

Cuno at Zaporojstal

Significant of the wide acceptance of Cuno Non-Stop Filtration in wartime steel mills is this installation in the Zaporojstal Steel Mill, U. S. S. R.

All four independent lubricating systems of this great mill — gear reducer, pinion stands, roll neck bearing, and motor bearing systems—are continuously protected by Cuno Auto-Klean Filters, guarding against solids in vital lubricating oil which, if not removed, would cause damage or excessive wear.

Typical of these four systems is the one shown below which supplies oil to the roll neck bearings. The full flow of oil having a viscosity of 2300 SSU at 100° F. passes through the Cuno filter at the rate of 650 GPM.

All Cuno Auto-Kleans are cleanable while in operation — manually or automatically by motor drive. The metal discs which do the filtering are permanent.

On the great majority of continuous hot and cold strip mills in American and foreign countries, Cunos safeguard peak wartime production.

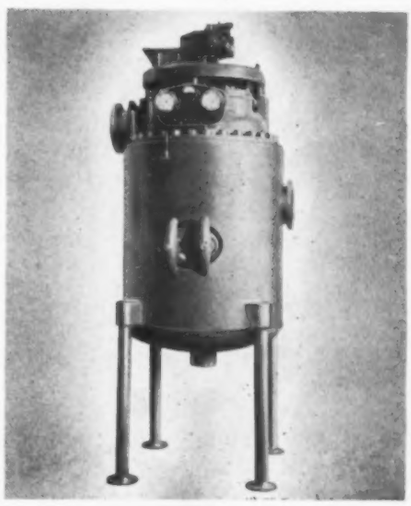
Write for free booklet "Quick Facts". Cuno Engineering Corp., 902 South Vine Street, Meriden, Connecticut.

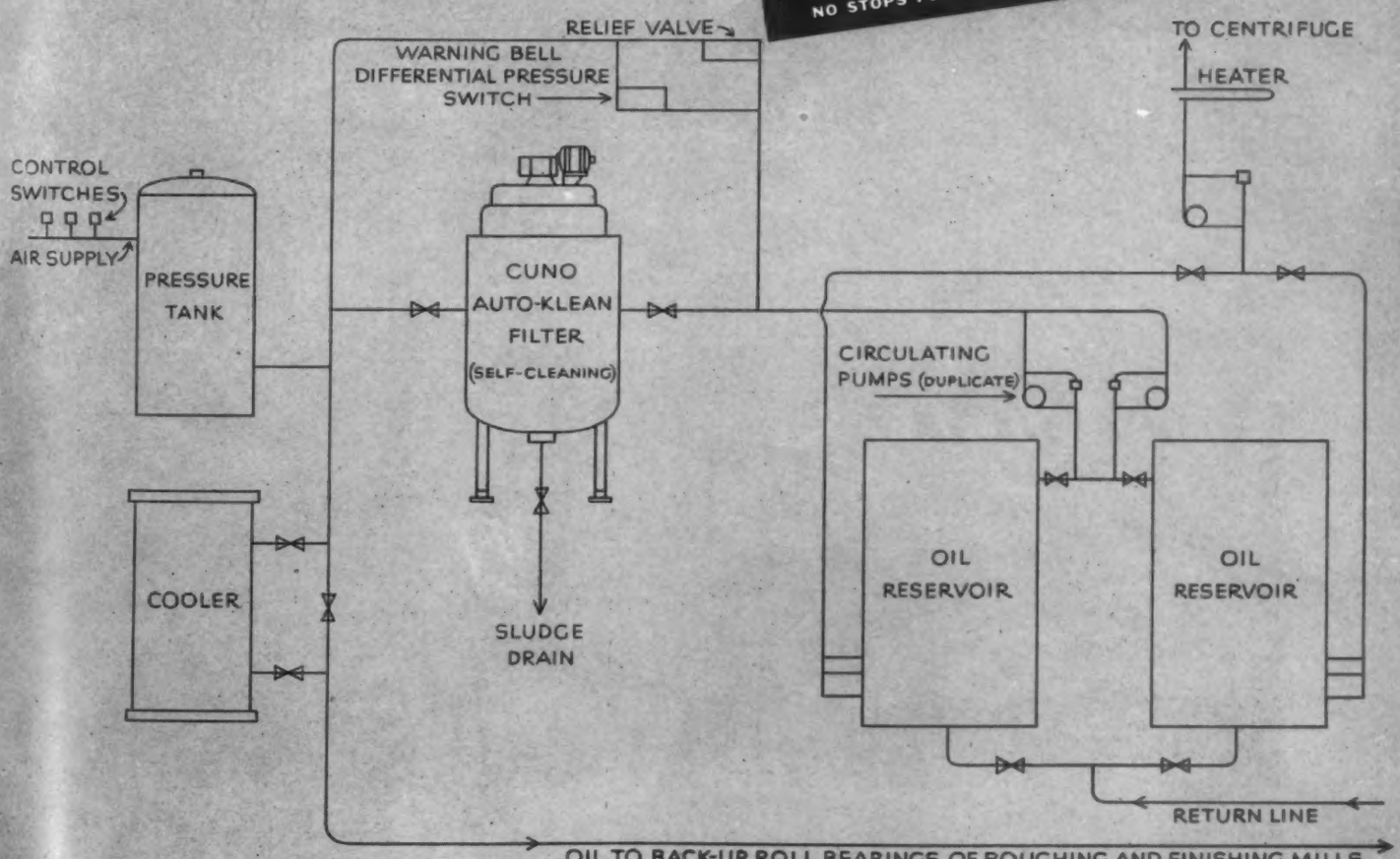
Non-Stop Production and Continuous Peak Protection

Cuno filters operate on edge-filtration principle— handle full-flow — are continuously cleanable (manually or automatically).

Cuno Auto-Klean (disc type): for lubricating and fuel oil systems as well as other industrial liquids.

Cuno Flo-Klean (wire-wound): designed especially for fluids of high abrasive content, i.e. descaling spray and roll body coolant systems.





NOW it's an Open and Shut Proposition

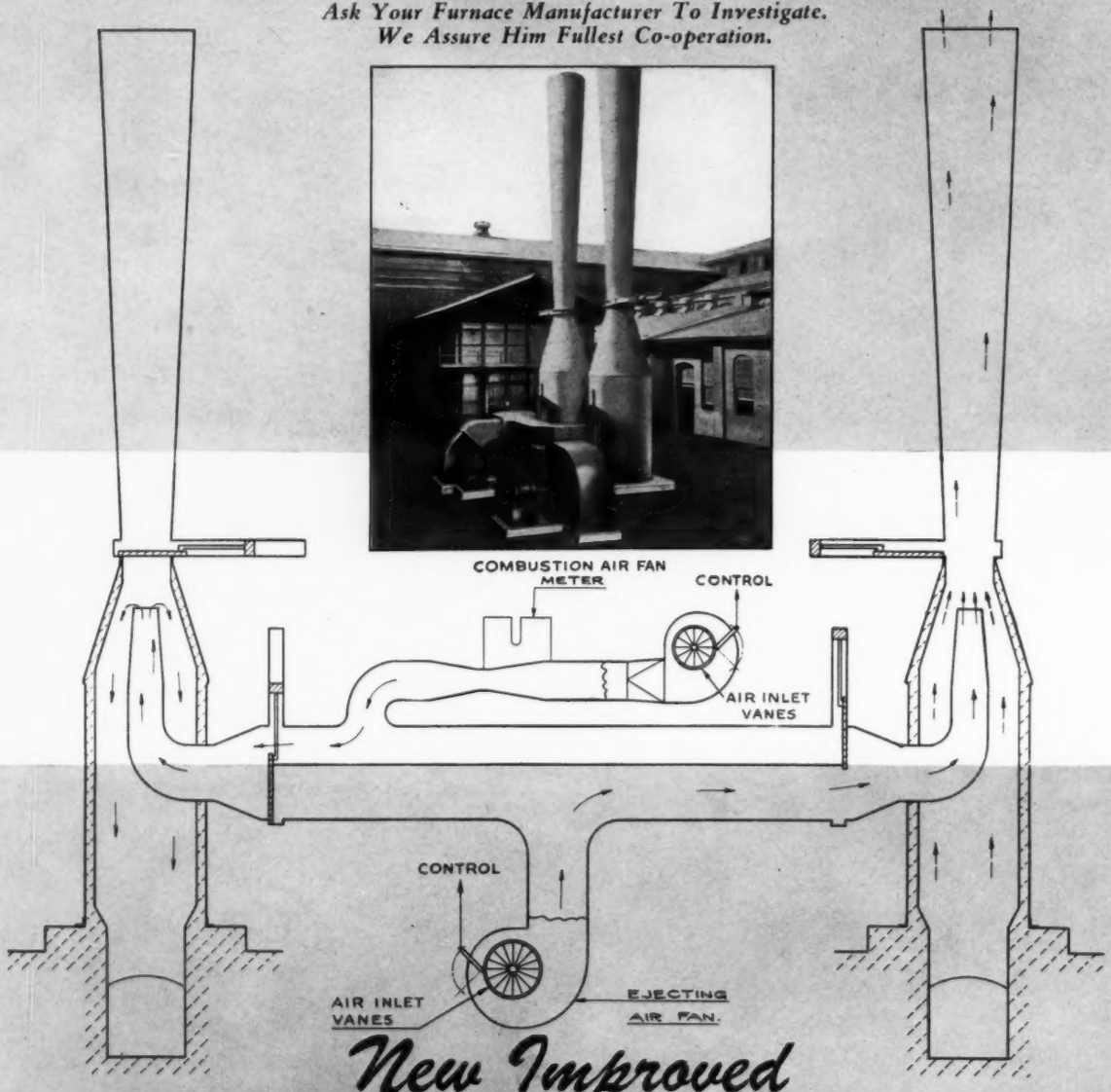
The Morgan Isley Airjector System, with its short stack, its powerful, positive, controlled draft, its 50% greater regenerative capacity, is recognized by industry as a tremendous improvement over the outdated tall stack and natural draft system. Now we announce an improvement on the improvement!

Briefly: A lower-powered motor is used exclusively for furnishing air for combustion, while a higher-powered motor is used for exhausting gases of combustion. Unlike the use of motors of equal capacity, this system, together with new slide-type dampers and automatic or manual operation, gives more exact stability of control and uses each motor's full capacity. No more uncertain adjustments for proportioning flows of air. It's an automatic "open and shut proposition"—the rugged, fool-proof, flexible and efficient answer to the melter's prayer.

MORGAN CONSTRUCTION COMPANY • WORCESTER, MASS.

Ask Your Furnace Manufacturer To Investigate.
We Assure Him Fullest Co-operation.

V-38



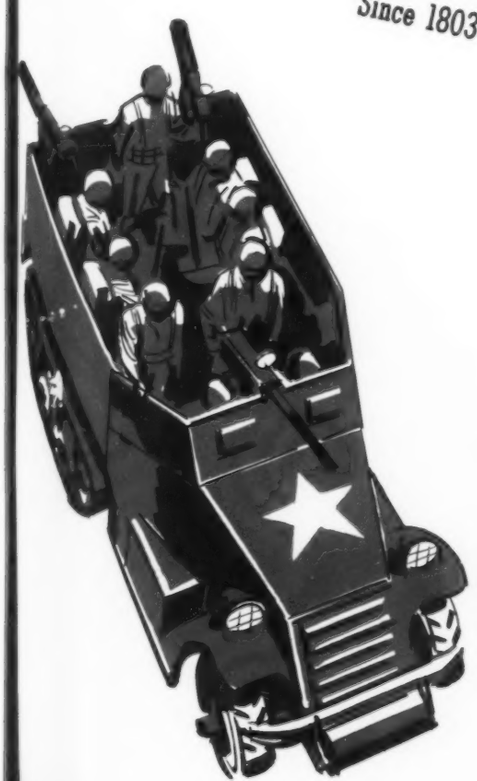
New Improved

ISLEY COMBUSTION CONTROL SYSTEM

resistance to slippage

The Rolls With The Red Wabblers . . .

"Techni" Process Rolls, Merchant and Bar Mill Rolls
give increased production, resistance to slippage,
more rolled tons between dressings.
"Techni" Process, an exclusive Mackintosh-Hemphill development,
provides greater strength, excellent finish,
unusual wearing qualities,
your roll-dollars call for "Techni" Process Rolls
Since 1803—Pioneers, Engineers and Builders



Mackintosh-Hemphill Company
Pittsburgh & Midland, Pennsylvania

Other Mackintosh-Hemphill Products:
Rolling Machinery . . . Shape Straighteners . . .
Strip Coilers . . . Shears . . . Levellers . . .
Pinions . . . Special Equipment . . . Iron-Steel Castings . . .
The NEW Abramsen Straightener . . .
Improved Johnston Patented
Corrugated Cinder Pots and Supports . . .
Heavy-Duty Engine Lathes

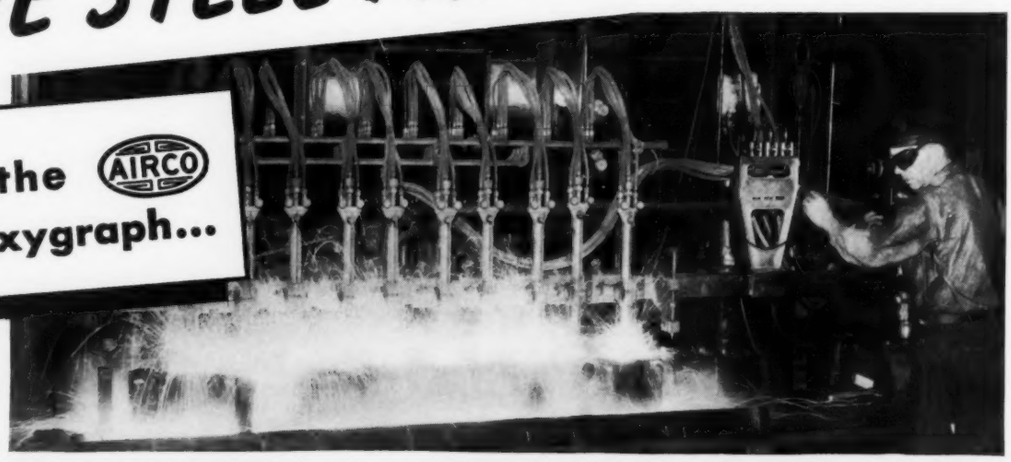
"Techni"

Process Iron and Steels

Base Rolls

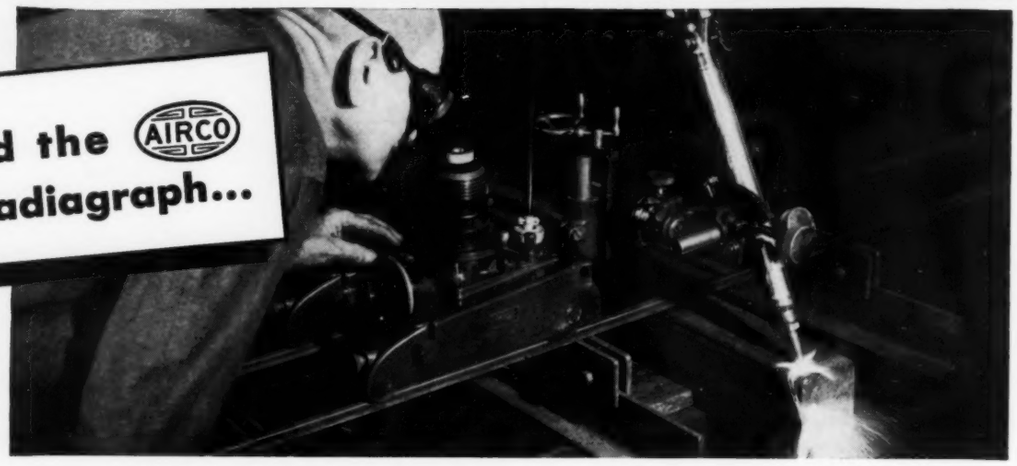
SHAPE STEEL FAST...

...with the AIRCO No. 6A Oxygraph...



No. 6A Oxygraph with ten torches, cutting seamless tubular headers at the rate of 100 per day for Combustion Engineering Co.

...and the AIRCO No. 4 Radiagraph...



An Airco No. 4 Radiagraph making a bevel cut in a steel bar, only one of many jobs within the range of this portable machine.

Reasonably prompt deliveries on relatively high priority ratings

These two Airco gas cutting machines are now available in limited quantities for essential work carrying relatively high preference ratings. Both machines have gained wide acceptance in metal working industries because of their precision, speed and wide range of uses.

The No. 6A Oxygraph is a stationary type gas cutting machine used for quantity production of metal parts. With a number of torches mounted on the machine, identical metal parts can be produced in quantity in a single cutting operation. Straight lines, bevels, or irregular shapes are cut from almost any commercial metal thickness quickly and accurately. A template of the required shape and size guides the movement of the mutliple cutting flames.

The Airco No. 4 Radiagraph is a remarkably versatile light weight (74 lbs. net), portable gas cutting machine which is widely used in steel mills, shipyards and other metal-working industries. It is motor driven and moves on a track placed upon the work. Straight line cuts, using one or two torches; beveled cuts with as many as three torches; circles and large radius curves are a few typical jobs performed by the Airco No. 4 Radiagraph.

For full information, prices, and delivery dates on both of these Airco machines get in touch with your nearest Air Reduction office.

Air Reduction

General Offices: 60 EAST 42nd ST., NEW YORK, N. Y.

IN TEXAS
MAGNOLIA-AIRCO GAS PRODUCTS CO.
General Offices: HOUSTON, TEXAS
OFFICES IN ALL PRINCIPAL CITIES

AIRCO WILSON

IDLE CYLINDERS ARE PRODUCTION SLACKERS: *Keep 'em rolling for victory!*

Follow this BASIC BEARING PRINCIPLE

★ for today's longer bearing life under continuous load!

★ for tomorrow's more compact design, more efficient performance, more economical maintenance!

★ for greater bearing capacity in any dimensional limit!

★ ROLLWAY'S RIGHT-ANGLED LOADING . . .
"better because it's simpler"

War has engineered complexity out of design, made simplicity a *"must"*. But in bearings—*the point around which most designs evolve*—Rollway's right-angle loading long ago reduced load problems to their two simplest components—*pure* radial and *pure* thrust.

The underlying principle is basic and universal. You *know* that every radial load and every thrust load is carried full-on, AT RIGHT ANGLES TO THE ROLLER AXIS. No oblique forces, no uncomputed resultants affect your design.

And every part of every load is supported by solid, cylindrical rollers of uniform cross-section. There's no weak point to invite stress localization, no wedging pressure, no danger of rollers pinching against the radius of the race.

Standard Sizes for Most Applications

S.A.E. or American Standard metric dimensions and tolerances are available for most applications . . . a wide range of sizes and types that are "engineered to the job." Avail yourself of Rollway's specialized bearing experience. Send your design or changeover sketch for free, confidential bearing analysis and recommendation. No obligation.

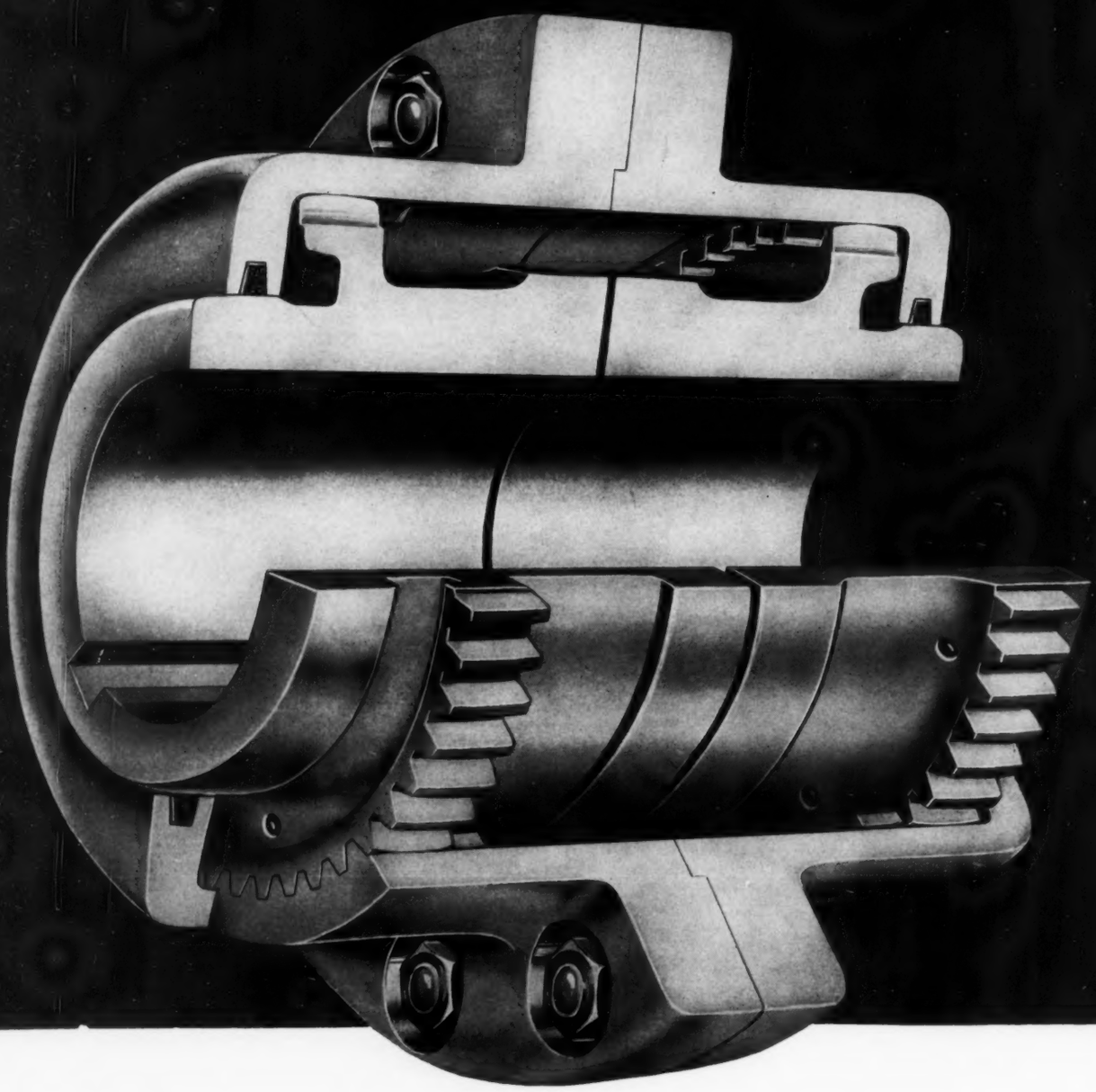
*TYPE MCS DOUBLE WIDTH RADIAL

*TYPE SDT DOUBLE ACTING THRUST

ROLLWAY BEARING COMPANY, INC., SYRACUSE, N. Y.

BUILDING HEAVY-DUTY BEARINGS SINCE 1908 — BEARINGS

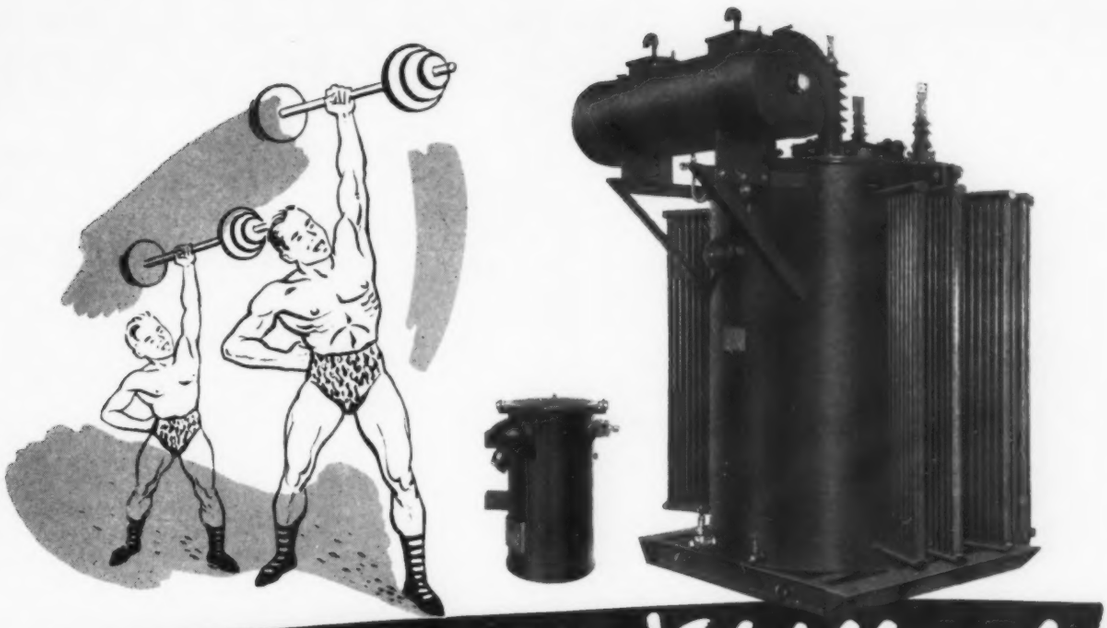
POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY WOODBERRY, BALTIMORE, MD.



Just Like His 'Ole' Man!

He's smaller in size and power, but his features are just like those of his "ole man". Yes, the good qualities that are built into Pennsylvania Power Transformers are found in equal measure in Pennsylvania Distribution Transformers.

FOR EXAMPLE:

1 CIRCULAR COILS Distribution as well as Power Transformers have Circular Coils. These coils have the maximum inherent mechanical and electrical strength and are balanced radially and axially against short circuit stresses.

2 VARNISH-TREATMENT No compounds are used in Pennsylvania Coils. Coils are treated in varnish at a maximum temperature of 105°C. This temperature leaves the insulation in a safe and pliable state. When baked, the varnish will not be affected by oil or heat.

3 BUILT-UP CORE LAMINATIONS Cores are constructed of 29 gauge, non-aging silicon steel. Individual laminations are insulated with a baked-on varnish. Since the entire core assembly is not treated in compound, the individual parts of the core can be disassembled and the coils removed.

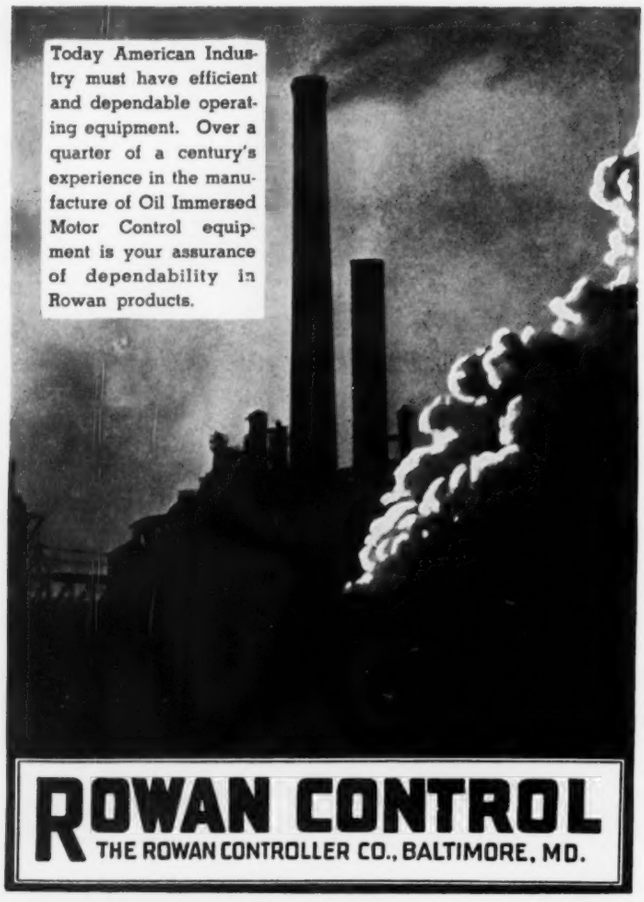
4 ROUND TANKS Round tanks and covers are fabricated of heavy copper-bearing steel. Small tanks have rolled tops and large tanks have heavy flange tops. The reinforced tops provide thickness and strength against deformation when the complete transformers are lifted by lugs.

5 WET PROCESS PORCELAIN BUSHINGS As in Power Transformers the bushings in Distribution Transformers are manufactured of wet process porcelain, and are easily detachable.

WRITE FOR YOUR COPY . . . of our new Catalog, No. 142, on Distribution Transformers.

Pennsylvania TRANSFORMER COMPANY
PITTSBURGH, PENNSYLVANIA

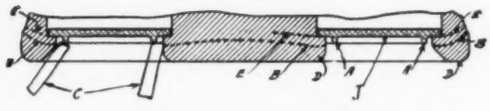
Pennsylvania TRANSFORMERS


Today American Industry must have efficient and dependable operating equipment. Over a quarter of a century's experience in the manufacture of Oil Immersed Motor Control equipment is your assurance of dependability in Rowan products.
ROWAN CONTROL
THE ROWAN CONTROLLER CO., BALTIMORE, MD.

Ohio Magnet Outer Rings Seldom Break

The bottom or wearing face of an Ohio Magnet presents a solid long lived surface to the work.

The annular rings on the manganese bottom plate prevent dangerous wear of steel pole shoes, so bottom plate cannot sag. See cut below.



Note wear line B B B

There are no holes or depressions to start wear or cracks.

These features result in

LOW MAINTENANCE COST.

OHIO Reliable MAGNETS

The OHIO Electric Mfg. Company

5907 Maurice Avenue

Cleveland · · Ohio

KEEP WAR PRODUCTION GOING AT TOP SPEED

by automatically lubricating all bearings on your machines

Equip your war production machines with

LINCOLN CENTRO-MATIC LUBRICATING EQUIPMENT

You can save man-power and man-hours, and at the same time cut down on bearing failures which prevent delays in producing war orders... How?... By automatically lubricating *every* bearing on a machine with a Lincoln Centro-Matic Lubricating System.

A Centro-Matic System consists of a number of Centro-Matic Injectors — one for each bearing — and a hand operated or a power operated Centro-Matic Lubricant Pump. A power operated system can be semi-automatic or it can be full automatic. The injectors can be grouped in manifold or located separately at each bearing. In either arrangement only a single lubricant supply line is required.

One of these systems is easily installed on new or old machines, and makes it possible to lubricate all bearings from a single source... Permits machines to run 7 days and 7 nights a week without taking time out for lubrication service... Write for details.

142-32

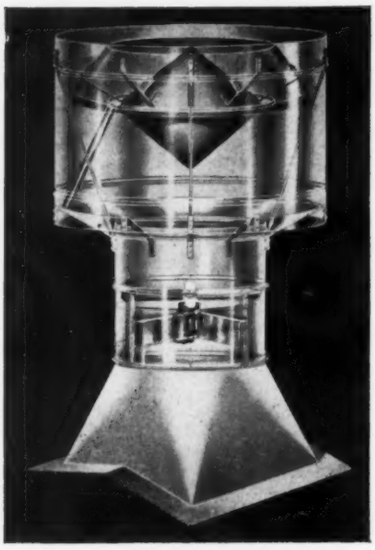
ARMY E NAVY

ARMY-NAVY PRODUCTION AWARD
for high achievement in the production of war equipment has been conferred upon the Lincoln Engineering Company. It serves as inspiration toward greater and greater accomplishment until the time of final and complete Victory.

★BUY U.S. WAR BONDS★

LINCOLN ENGINEERING COMPANY • ST. LOUIS, MO.

—BURT—
VENTILATORS



FREE-FLOW FAN TYPE

Speed The Day of Victory

The steel mill equipped with Burt Ventilators is better set for top production than the one burdened with impure, fume-laden air. Burt Ventilators contribute to increase output, decrease accidents, improve the comfort and morale of workers. The Free-Flow Fan type, shown above, is particularly designed to move a large volume of hot fume-laden air from a definite locality. Its capacity is several times that of gravity ventilators of the same size.

Burt makes three types specially adapted for steel mill installations, — Free-Flow Fan, Free-Flow Gravity and the Monovent Continuous Ridge Ventilator. All are scientifically designed for high efficiency and sturdily built to give long dependable service.

Send for data sheets and job references. Do not hesitate to call on Burt Engineers for assistance in estimating and laying out plans.

THE BURT MFG. CO.
ROOF VENTILATORS • OIL FILTERS
EXHAUST HEADS
950 SOUTH HIGH STREET AKRON, OHIO

SEND FOR CATALOGS
•
Burt Engineers are glad to help on plans

Keep Portable Tools In Steady Service

Efficient, full-time operation of portable tools is essential to speediest production.

Leading makers* of air and electric tools use and recommend NON-FLUID OIL. Prolonged service tests proved it helped their tools perform most effectively. This has been borne out by experience in hundreds of plants.

NON-FLUID OIL will help increase production in your plant and save on repair and maintenance cost. What's more, it will reduce lubricant and application cost by outlasting common greases.

Used successfully in leading iron and steel mills. Send for instructive bulletins.

** Names on request.*

•

New York & New Jersey Lubricant Co.

Main Office: 292 Madison Ave., New York, N. Y.

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St. Louis, Mo. — Detroit, Mich.
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TRADE MARK REGISTERED
NON-FLUID OIL
IN U.S. PAT. OFFICE & FOREIGN COUNTRIES

MODERN STEEL MILL LUBRICANT

Better Lubrication at Less Cost per Month

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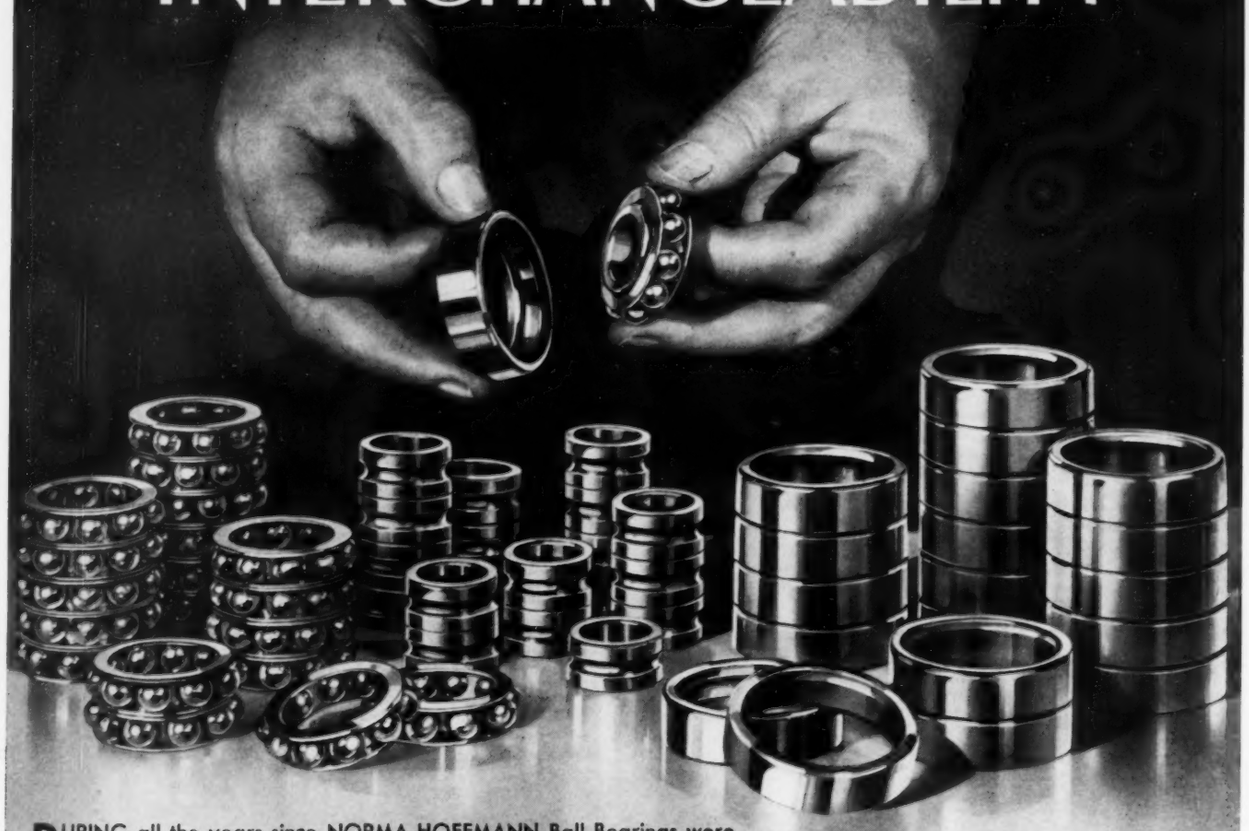
A THIRD OF A CENTURY of INTERCHANGEABILITY



DURING all the years since NORMA-HOFFMANN Ball Bearings were introduced, PRECISION has been their distinguishing feature.

"But"—we are often asked—"has this PRECISION been unvarying, over all these years?"

An actual test of the INTERCHANGEABILITY maintained in day-after-day, year-after-year NORMA-HOFFMANN production would (we believed) give a convincing answer to the question—since, in the bearing world, INTERCHANGEABILITY of parts cannot be realized unless PRECISION is maintained.

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In every case, we found the reassembled unit to be a true NORMA-HOFFMANN PRECISION Ball Bearing, with internal accuracy unchanged and in every respect conforming to our exacting standards.

This is NORMA-HOFFMANN PRECISION—not new or variable or "special"—but a time-tested, inflexible standard of quality. This PRECISION is YOUR assurance of bearing speed-ability and service-ability—YOUR safeguard against bearing troubles.

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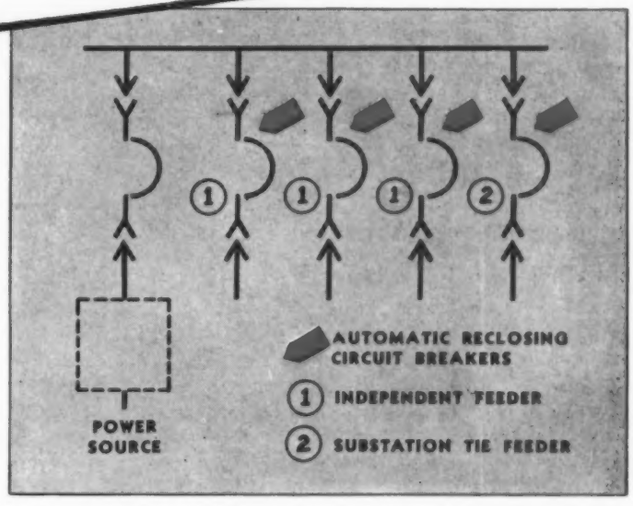
News of Electrical Protection

Automatic Reclosing Circuit Breakers in Steel Mills

AMONG STEEL-MILL ENGINEERS there is evidence of growing interest in the advantages of automatic reclosing circuit breakers. The interest centers on applications for those d-c auxiliary systems on which, after outage, it is safe and otherwise desirable to have service restored at the instant a fault has been cleared.

Like other electrical developments for steel-mill practice, this trend stems from study of steel-mill conditions. Steel men have a way of searching within their own problems for better answers and then finding them. But were any check needed within other industries to indicate the lasting values of automatic reclosing circuit breakers, there is a long history. The art is thoroughly established.

The basic purpose of using automatic reclosing circuit breakers on steel-mill d-c auxiliary systems is the same as for any other application—to gain the best continuity of service. This is achieved not only by having power restored, after outage, at the earliest possible second, but also by confining an interruption to the local area in which a fault arises. War-time pressure for peak production has proved to steel men, as to others, that it is sound and enduring economy to keep interruptions from being needlessly prolonged and from affecting a needlessly large mill area.



Schematic diagram indicating use of automatic reclosing circuit breakers on feeders and for sectionalizing a tie-line to another substation.

Make a note of automatic reclosing circuit breakers. Steel mills will be using more of them. Keep them in mind for long-range plans. I-T-E engineers, whose experience dates from pioneering installations years ago, will help you.

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No single enclosed or explosion-proof motor is recommended for all types of hazardous service. General Electric has pioneered in producing a family of motors to meet the dangers of specific gases, vapors, liquids, and dusts. For some hazards, only G-E motors are listed by Underwriters' Laboratories, Inc. Our engineering staff can help you pick the *right* motor, control, and other auxiliary equipment for uninterrupted war production.

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